GE Medical Systems

Technical Publications

2202124

Revision 7

CT HiSpeed Series Theory of Operation

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Operating Documentation

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- **THIS SERVICE MANUAL IS AVAILABLE IN ENGLISH ONLY.**
- **IF A CUSTOMER'S SERVICE PROVIDER REQUIRES A LANGUAGE OTHER THAN ENGLISH, IT IS THE CUSTOMER'S RESPONSIBILITY TO PROVIDE TRANSLATION SERVICES.**
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- **LE NON-RESPECT DE CET AVERTISSEMENT PEUT ENTRAÎNER CHEZ LE TECHNICIEN, L'OPÉRATEUR OU LE PATIENT DES BLESSURES DUES À DES DANGERS ÉLECTRIQUES, MÉCANIQUES OU AUTRES.**

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AVISO

- **ESTE MANUAL DE SERVICIO SÓLO EXISTE EN INGLÉS.**
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- **ESTE MANUAL DE ASSISTÊNCIA TÉCNICA SÓ SE ENCONTRA DISPONÍVEL EM INGLÊS.**
- **SE QUALQUER OUTRO SERVIÇO DE ASSISTÊNCIA TÉCNICA, QUE NÃO A GEMS, SOLICITAR ESTES MANUAIS NOUTRO IDIOMA, É DA RESPONSABILIDADE DO CLIENTE FORNECER OS SERVIÇOS DE TRADUÇÃO.**
- **NÃO TENTE REPARAR O EQUIPAMENTO SEM TER CONSULTADO E COMPREENDIDO ESTE MANUAL DE ASSISTÊNCIA TÉCNICA.**
- **O NÃO CUMPRIMENTO DESTE AVISO PODE POR EM PERIGO A SEGURANÇA DO TÉCNICO, OPERADOR OU PACIENTE DEVIDO A‘ CHOQUES ELÉTRICOS, MECÂNICOS OU OUTROS.**

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- **IL PRESENTE MANUALE DI MANUTENZIONE È DISPONIBILE SOLTANTO IN INGLESE.**
- **SE UN ADDETTO ALLA MANUTENZIONE ESTERNO ALLA GEMS RICHIEDE IL MANUALE IN UNA LINGUA DIVERSA, IL CLIENTE È TENUTO A PROVVEDERE DIRETTAMENTE ALLA TRADUZIONE.**
- **SI PROCEDA ALLA MANUTENZIONE DELL’APPARECCHIATURA SOLO DOPO AVER CONSULTATO IL PRESENTE MANUALE ED AVERNE COMPRESO IL CONTENUTO.**
- **NON TENERE CONTO DELLA PRESENTE AVVERTENZA POTREBBE FAR COMPIERE OPERAZIONI DA CUI DERIVINO LESIONI ALL’ADDETTO ALLA MANUTENZIONE, ALL’UTILIZZATORE ED AL PAZIENTE PER FOLGORAZIONE ELETTRICA, PER URTI MECCANICI OD ALTRI RISCHI.**

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- 未详细阅读和完全了解本手册之前，不得进行维修。
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Although this apparatus incorporates a high degree of protection against x-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly exposing themselves or others to radiation.

It is important that everyone having anything to do with x-radiation be properly trained and fully acquainted with the recommendations of the National Council on Radiation Protection and Measurements as published in NCRP Reports available from NCRP Publications, 7910 Woodmont Avenue, Room 1016, Bethesda, Maryland 20814, and of the International Commission on Radiation Protection, and take adequate steps to protect against injury.

The equipment is sold with the understanding that the General Electric Company, Medical Systems Group, its agents, and representatives have no responsibility for injury or damage which may result from improper use of the equipment.

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CERTIFIED ELECTRICAL CONTRACTOR STATEMENT

All electrical installations that are preliminary to positioning of the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations, and testing shall be performed by qualified GE Medical personnel. The products involved (and the accompanying electrical installations) are highly sophisticated, and special engineering competence is required.

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All packages should be closely examined at time of delivery. If damage is apparent, have notation "**damage in shipment**" written on **all** copies of the freight or express bill **before** delivery is accepted or "signed for" by a General Electric representative or a hospital receiving agent. Whether noted or concealed, damage **MUST** be reported to the carrier **immediately** upon discovery, or in any event, within **14** days after receipt, and the contents and containers held for inspection by the carrier. A transportation company will not pay a claim for damage if an inspection is not requested within this **14** day period.

Call Traffic and Transportation, Milwaukee, WI (414) 827–3449 / 8*285–3449 **immediately** after damage is found. At this time be ready to supply name of carrier, delivery date, consignee name, freight or express bill number, item damaged and extent of damage.

Complete instructions regarding claim procedure are found in Section "S" of the Policy & Procedure Bulletins.

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GE personnel, please use the GEMS CQA Process to report all omissions, errors, and defects in this documentation. Customers, please contact your GE Sales or Service representatives.

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Devices not to be used near this equipment:

Devices which intrinsically transmit radio waves such as; cellular phone, radio transceiver, mobile radio transmitter, radio–controlled toy, etc.

Keep power to these devices turned off when near this equipment.

Medical staff in charge of this equipment is required to instruct technicians, patients and other people who may be around this equipment to fully comply with the above regulation.

REVISION HISTORY

REV	DATE	PRIMARY REASON FOR CHANGE
0	Mar. 27, 1998	Initial release.
1	Jul. 10, 1998	Updated System option description; Added 200VPDU, Scan Operation, NAA1 block diagram, ST–1800 description; Generally updated DAS and XG.
2	Aug. 31, 1998	Revised Table/Gantry, DAS/Detector tabs.
3	Nov. 27, 1998	OC Vide signal specifications, other.
4	Feb. 26, 1999	Hard disk capacity.
5	Oct. 19, 1999	Added information about NP++ (HiSpeed ZX/i).
6	Dec. 17, 1999	Added a Jedi (for NP++) block diagram.
7	Feb. 25, 2000	200VPDU note.

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SYSTEM

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SECTION 1 – GENERAL DESCRIPTION

1-1 INTRODUCTION

The features of this CT (Computed Tomography) system, one of the HiSpeed series CT scanners, include the following:

Workstation type information processing system,
Solid–state x–ray intensity detector,
Continuous rotation type gantry with slip rings and high frequency coupling.

This CT system is comprised of the following main components (called subsystems):

- Operator Console (called OC)
- Scanning Gantry (called gantry)
  This subsystem further includes the following subsystems:
  - DAS/Detector
  - X–ray Generator (called XG)
- Patient Table (called table)
- Power Distribution Unit (called PDU)

The system may include some of the following customer option equipments:

- Advantage Windows Image Workstation
- Image Camera

1-2 HARDWARE CONSTITUTION OF NP, NP+, AND NP++

Product Code Name

According to product models or customer options installed on the system, a number of system specifications or functions available may differ from system to system; such are:

- Selectable scan times, MA values, FOV dimensions
- 'Remote Tilt' function
- Number of detector active channels (this difference results in image spatial resolution)
- ...

However, the 'HiSpeed' series scanners can be principally grouped into three, for which the following code names are given respectively:

'NP', 'NP+' and 'NP++'

In this 'Theory of Operation' manual, these code names NP, NP+ and NP++ are used to describe differences among these three groups and to make descriptions of this manual read simpler.

Table 1–1 describes the constitution of the major hardware of NP, NP+, NP++.

Table 1–1 Hardware Constitution

Subsystem/Component		NP	NP+	NP++
OC	–	common		
Gantry	Mechanics – Positioning Light	Halogen Lamps	Laser	
	Mechanics – others	common		
	Electrics	Firmware only is different.		
Table	IMS (Intermediate Support)	Standard or Option		Standard
	Others	common		
DAS	–	common		
Detector	–	common (Cast Lumex)		
X–ray Generator	–	common (Jedi)		Gemini Jedi
X–ray Tube	–	common (MX165: modified EA Tube)		Gemini Tube
PDU	–	common		

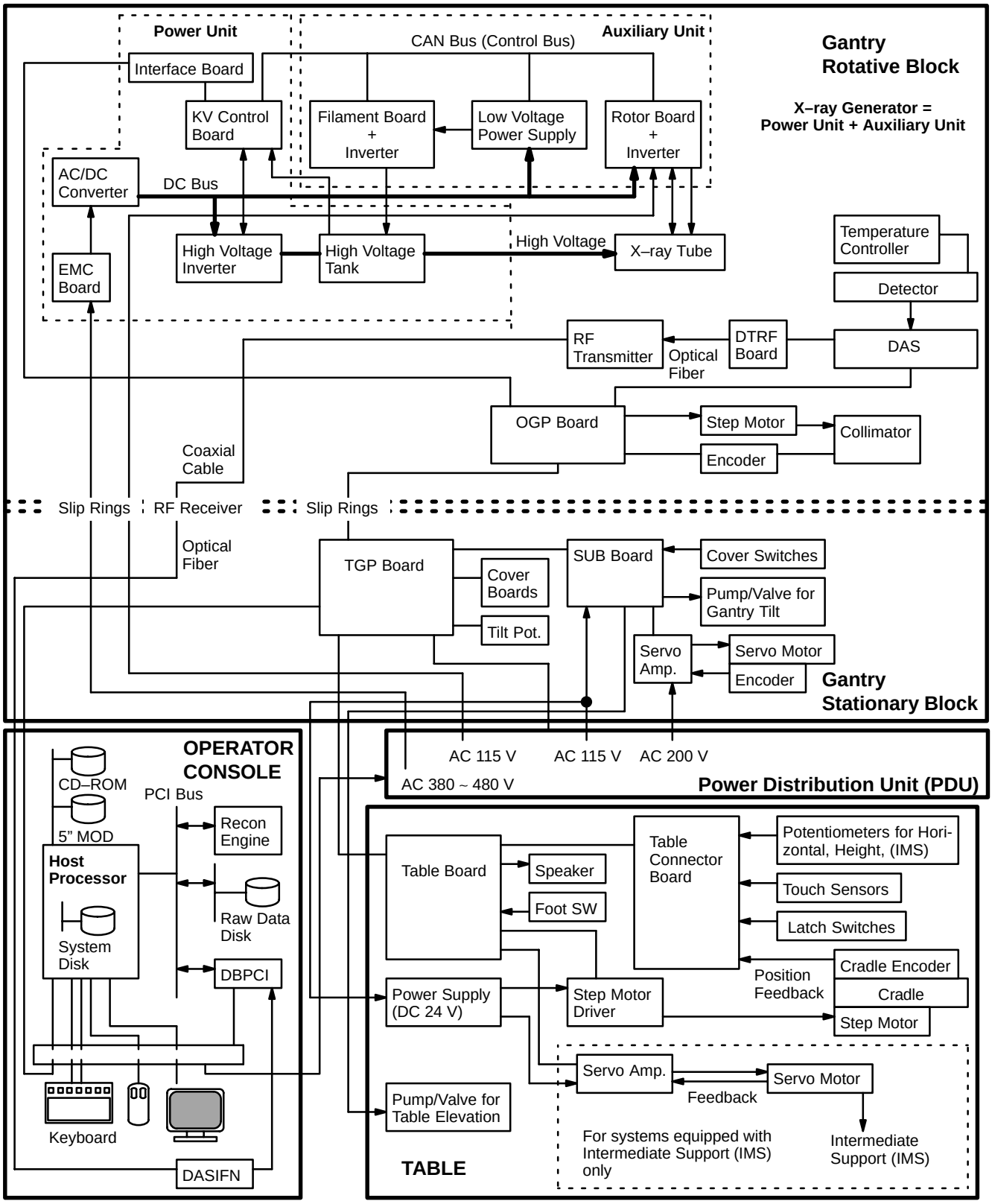
1-3 SYSTEM OVERVIEW

Illustration 1–1 shows the system block diagram.

The operator console (OC) controls the entire system, according to the operator's operations. The OC sends instructions to the processor of the TGP board, which then controls the gantry and table subsystems according to the instructions.
The TGP board processor also passes the OC instructions to the processor of the OGP board which is equipped on the gantry rotative frame. The OGP board controls the DAS subsystem, the collimator aperture, or positioning lights according to the passed instructions.
The OGP board processor also passes the instructions from the TGP board to the processor of the x–ray generator subsystem. The XG processor controls the x–ray generator according to the instructions (originally from the OC).

Reversely, the OC receives status information from the TGP board or other processors (via the TGP board).

Illustration 1–1 System Block Diagram



1-4 SYSTEM SPECIFICATIONS AND DATA

The following tables describe system specifications and data.

Table 1–2 Scan Time

Scan Time [sec]			
Standard (NP, NP+)	**with 1.0 sec Scan Option**	**with 0.8 sec Scan Option**	**Standard (NP++)**
–	–	0.5 (Half scan)	0.46 (Half scan)
–	0.7 (Half scan)	0.8	0.7
1.0 (Half scan)	1.0	1.0	1.0
1.5	1.5	1.5	1.5
2.0	2.0	2.0	2.0
3.0	3.0	3.0	3.0

Table 1–3 Scan/Recon/Cal FOV

FOV for NP [cm]		FOV for NP+ and NP++ [cm] (or, for NP with 50 cm FOV Option)	
Scan/Recon FOV	**Cal FOV**	**Scan/Recon FOV**	**Cal FOV**
P–Head (18)	Small (25)	P–Head (18)	Small (25)
Head (25)	Small (25)	Head (25)	Small (25)
Body (45.5)	Large (50)	Body (50)	Large (50)

Table 1–4 Image Spatial Resolution Related

No. of Actual Scan Views		No. of Detector Active Channels		Recon Matrix
Full Scan	**Half Scan**	**NP**	**NP+, NP++**	**NP, NP+, NP++**
972	635	717	793	512 X 512
For 50 cm or 45.5 cm scan FOV		The same type detector is used both for NP and NP+; the difference between the numbers of active channels is realized by software.		

1-4 SYSTEM SPECIFICATIONS AND DATA (continued)

Table 1–5 KV–MA Stations

KV	MA					
	Standard		with 200 mA Option		with 300 mA Option	
	LF	SF	LF	SF	LF	SF
80	60	60	60	60	60	60
	80	80	80	80	80	80
	100	100	100	100	100	100
	130	130	130	130	130	130
	150	150	150	150	150	150
			200	200	200	200
					250	250
					300	
120	10	10	10	10	10	10
	60	60	60	60	60	60
	80	80	80	80	80	80
	100	100	100	100	100	100
	130	130	130	130	130	130
	150	150	150	150	150	150
			200	200	200	200
					250	
					300	
140	10	10	10	10	10	10
	60	60	60	60	60	60
	80	80	80	80	80	80
	100	100	100	100	100	100
	130	130	130	130	130	130
	150	150	150	150	150	150
			200		200	
					250	

LF: Large Focus **SF:** Small Focus

Note: MA can also be set to any value that falls between the specified minimum and maximum values (as listed above), in 10 mA increments.

1-4 SYSTEM SPECIFICATIONS AND DATA (continued)

The system automatically selects Large Focus or Small Focus according to a slice thickness selection as described in Table 1–6.

Table 1–6 Combination of Slice Thickness and Focus Size (for Customer)

Slice Thickness [mm]	Focus Size
1, 2	Small
3, 5, 7, 10	Large

Table 1–7 Other Specifications

Exposure Start Angle (Axial Scan)
Head & Posteriafossa Studies:
90/270 deg.
Other Studies:
0/180 deg.

1-5 SYSTEM OPTIONS

Table 1–8 Main System Options for NP and NP+

Category		Name	Description
Scan/Recon	High speed scan	• Fast Scan 1.0 sec • Fast Scan 0.8 sec	–
	Large MA	• Power Option 200 mA • Power Option 250 mA • Power Option 300 mA • Power Option 350 mA	–
	Helical scan	• 30 Slice Helical • 60 Slice Helical • 120 Slice Helical	–
	High speed recon	• Fast Recon 1 • Fast Recon 2 • Fast Recon 3	Speeds up recon time from 6 sec to 4 sec. Speeds up recon time from 4 sec to 2 sec. Speeds up recon time from 6 sec to 2 sec.
Storage Device	Hard disk drive (HDD)	• Additional HDD for image storage • Ext Raw Data Disk	– Additional HDD for raw data storage
	Main memory for Host processor	• 256 MB • 512 MB	–
	Magnetic optical disk drive (MOD)	• MOD	Additional Pioneer MOD
Filming	Laser camera	• Analog interface • Digital interface	–
Network	Ethernet	• Advantage Windows	–
Software		• 3D Imaging • Denta Scan • Navigator • Smart Helical	–
Other option for Operator Console		• Foot switch for Inter-com	–
Options for Gantry		• Rear operation panel • Front touch censor	–

1-5 SYSTEM OPTIONS (continued)

Table 1–9 Main System Options for NP++

Category		Name	Description
Storage Device	Main memory for Host processor	• 512 MB	–
	Magnetic optical disk drive (MOD)	• MOD	Additional Pioneer MOD
Filming	Laser camera	• Analog interface • Digital interface	–
Network	Ethernet	• Advantage Windows	–
Software		• 3D Imaging • Denta Scan • Navigator • Smart Helical	–
Other option for Operator Console		• Foot switch for Inter-com	–
Options for Gantry		• Rear operation panel • Front touch censor	–

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SECTION 2 – POWER DISTRIBUTION

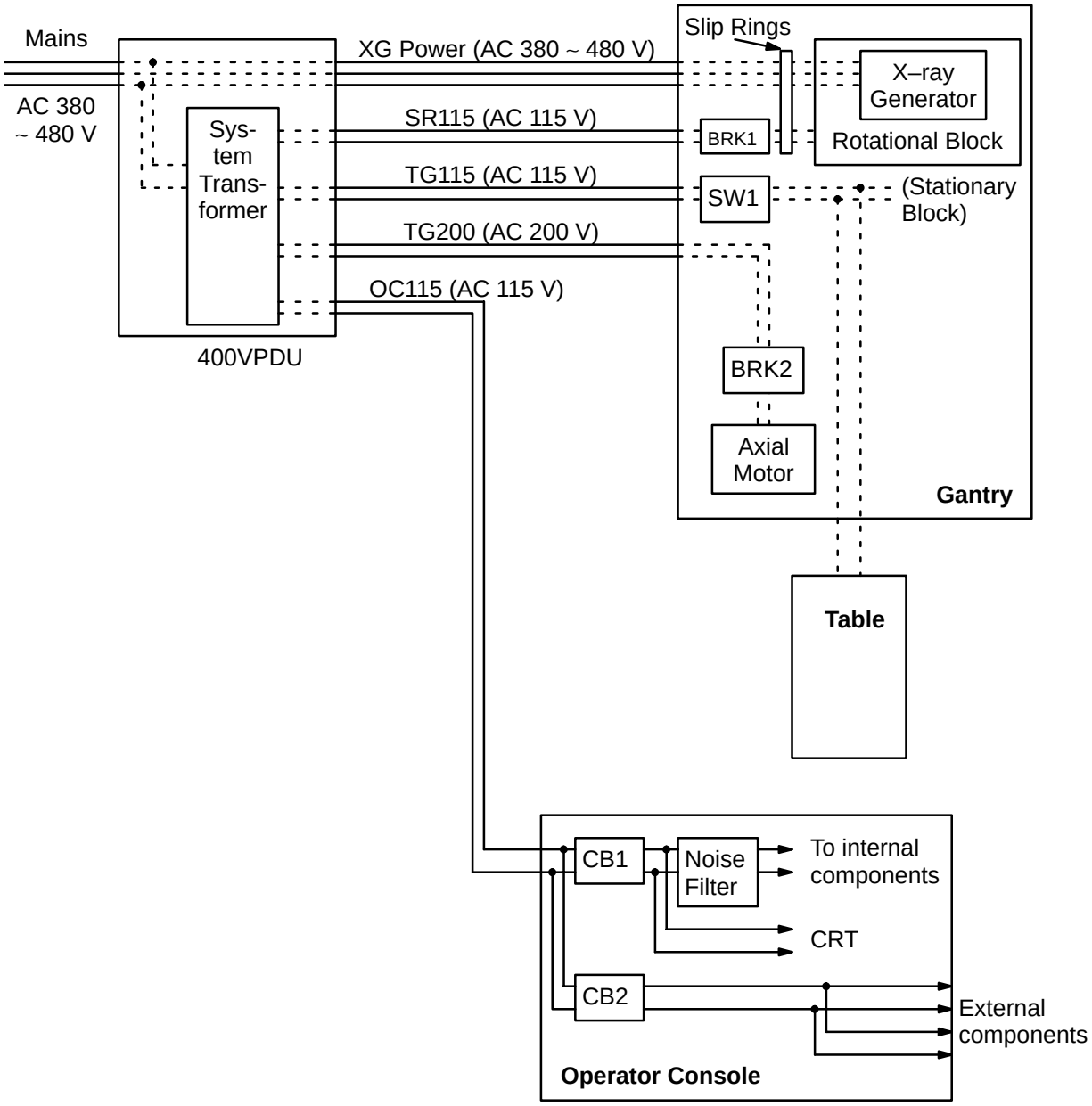
2-1 POWER DISTRIBUTION UNIT (PDU)

The power distribution unit (PDU) provides powers to all the subsystems.
Two types of PDUs are available: 400VPDU and 200VPDU. Either one of two types is used according to the mains voltage (main power from the power distribution box of sites). (200VPDUs are used in Japan only.)
See Illustration 2–1 (400VPDU) or 2–2 (200VPDU). These illustrations describe the following:

- All the powers except ‘XG Power’ are output from the system transformer on the PDU. (200VPDUs generate ‘XG Power’ by a step–up transformer.)
- ‘XG Power’ powers the x–ray generator (XG) equipped on the gantry rotational block. Powers for x–ray tube high voltage, x–ray tube anode rotation, XG control circuit boards, etc. are derived from this power. However, the fan and pump for the x–ray tube are powered by ‘SR115.’
- ‘SR115’ powers all the components equipped on the gantry rotational block except the x–ray generator.
- ‘TG115’ powers all the components equipped on the gantry stationary block except the axial motor. The gantry tilt pump also is operated by this power. ‘TG115’ also powers the table subsystem.
- ‘TG200’ powers the axial motor which rotates the gantry rotational block.
- ‘OC115’ supplies power to the operator console.

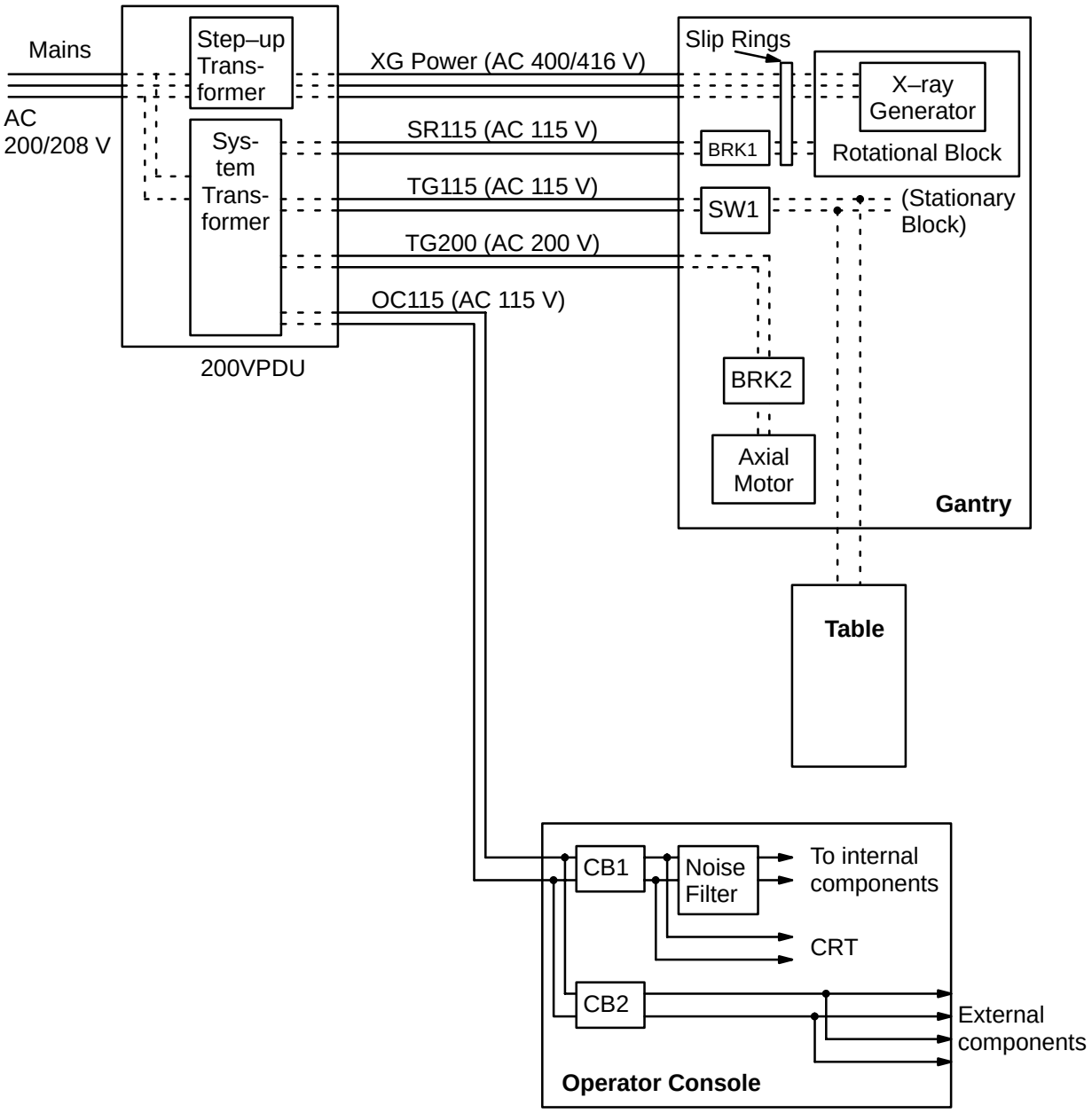
2-1 POWER DISTRIBUTION UNIT (PDU) (continued)

Illustration 2–1 Power Distribution to Subsystems (400VPDU)



2-1 POWER DISTRIBUTION UNIT (PDU) (continued)

Illustration 2–2 Power Distribution to Subsystems (200VPDU)



2-1 POWER DISTRIBUTION UNIT (PDU) (continued)

Illustration 2–3 (400VPDU) or 2–4 (200VPDU) shows the simplified circuit diagram of the PDU.
As shown;

- **(400VPDU):**
  The voltage of mains power should be within a range of 380 V ~ 480 V. The system transformer provides terminals for 380 V, 400 V, ... , 480 V to connect power to the nearest voltage terminal.

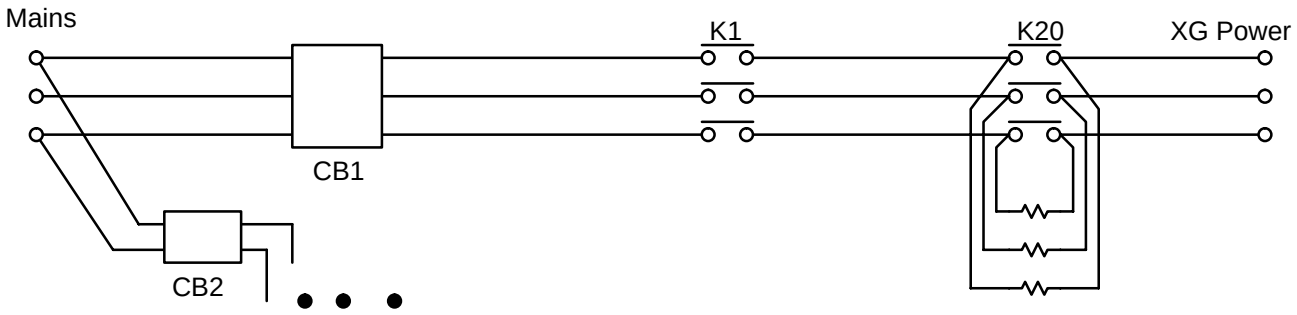
- **(200VPDU):**
  The system transformer provides terminals for 200 V and 208 V to connect power to the nearest voltage terminal.

- The 'SR115' output is not controlled by any relay contacts; the power is always present in the CT system unless circuit breakers CB2 or CB5 are turned off.

- The RMT CNT board contains relays which turn on/off K5, K6, K7, or K19 according to signals from the operator console and gantry.

- The relay K1 is turned on some delay time later after K21 is turned on.
  The resisters connected to the relay K21 suppress rush currents.

  Earlier PDU models have the following circuits between Mains and XG Power, instead of the circuits shown in Illustration 2–3 or 2–4. (The relay K20 is turned on some delay time later after K1 is turned on. The resisters connected to the relay K20 suppress rush currents.)

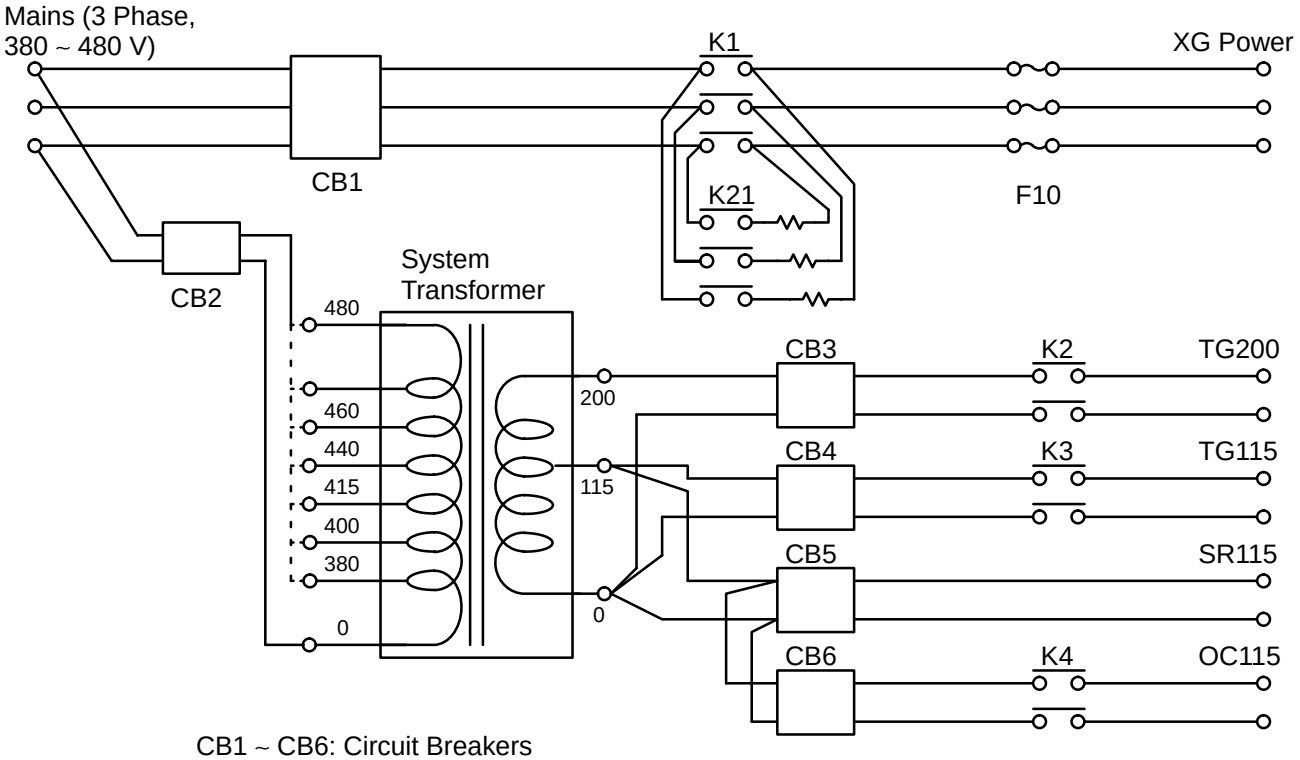


  However, the further earlier PDU models do not have K20 and connected resisters.

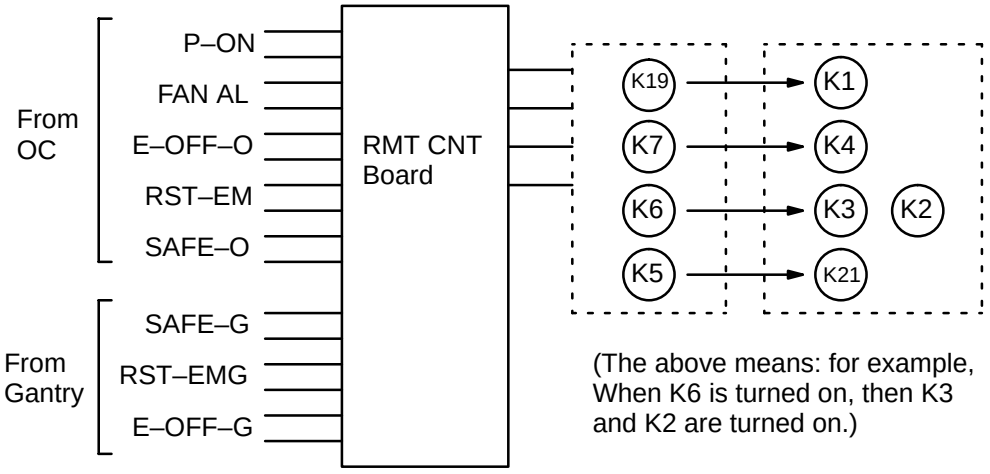
- Circuit breakers CB1, CB2, ... , CB6 can turn OFF powers, as written below:
  - CB1: XG Power
  - CB2: TG200, TG115, SR115, OC115
  - CB3: TG200
  - CB4: TG115
  - CB5: SR115
  - CB6: OC115

2-1 POWER DISTRIBUTION UNIT (PDU) (continued)

Illustration 2–3 Inside of PDU (400VPDU)



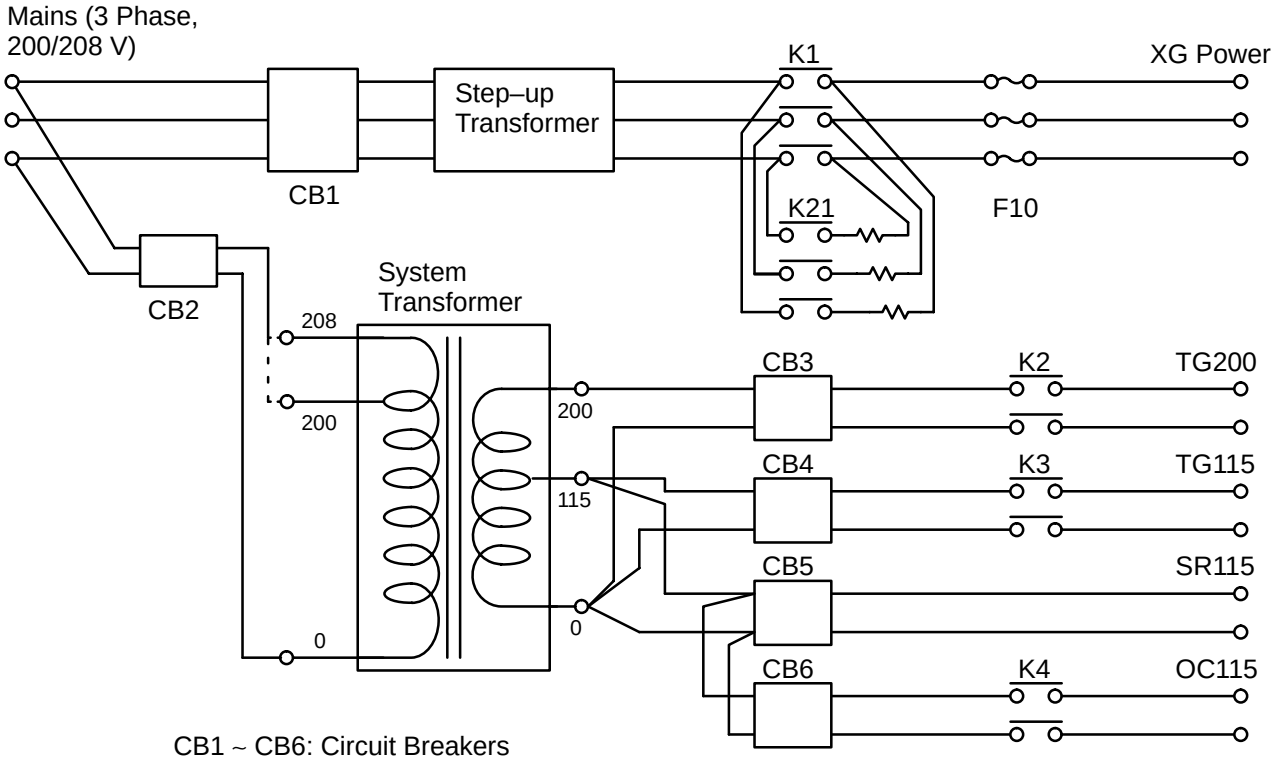
CB1 ~ CB6: Circuit Breakers

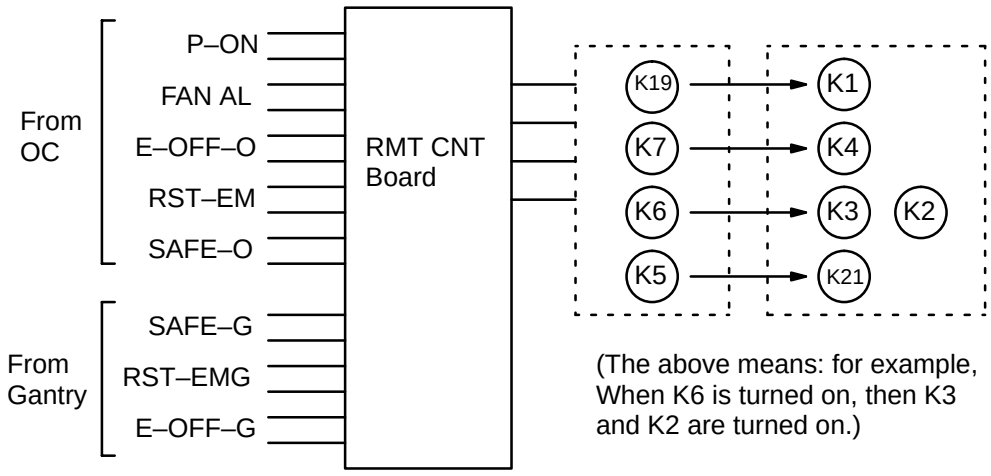


(The above means: for example, When K6 is turned on, then K3 and K2 are turned on.)

2-1 POWER DISTRIBUTION UNIT (PDU) (continued)

Illustration 2–4 Inside of PDU (200VPDU)





(The above means: for example, When K6 is turned on, then K3 and K2 are turned on.)

2-2 POWER DISTRIBUTION SEQUENCE

2-2-1 Power On/Off Timing Chart

The power on/off controls of ‘XG Power’, ‘TG200’, ‘TG115’, etc. shown in Illustration 2–1 or 2–3 (or, 2–2 or 2–4, for 200VPDU) are shown in Illustration 2–5.

In the illustration;
‘E–OFF’ turns ‘close’ or ‘open’ when either ‘E–OFF–O’ or ‘E–OFF–G’ turns ‘close’ or ‘open.’
That ‘Safety Loop’ turns ‘close’ or ‘open’ means the system safety loop is closed or opened, including both ‘SAFE–O’ and ‘SAFE–G’ turns ‘close’ or ‘open.’ (See the ‘Safety Loop’ description on page 2–10)
‘Reset Emergency’ turns ‘close’ or ‘open’ when either ‘RST–EM’ or ‘RST–EMG’ turns ‘close’ or ‘open.’

Illustration 2–5 describes the following:

- Timing B:
  Only when ‘Safety Loop’ turns ‘close’, ‘XG Power’ turns ON.

- Timing E:
  When ‘E–OFF’ turns ‘open’, ‘XG Power’, ‘TG200’, and ‘TG115’ turn OFF; however, ‘OC115’ remains ON.

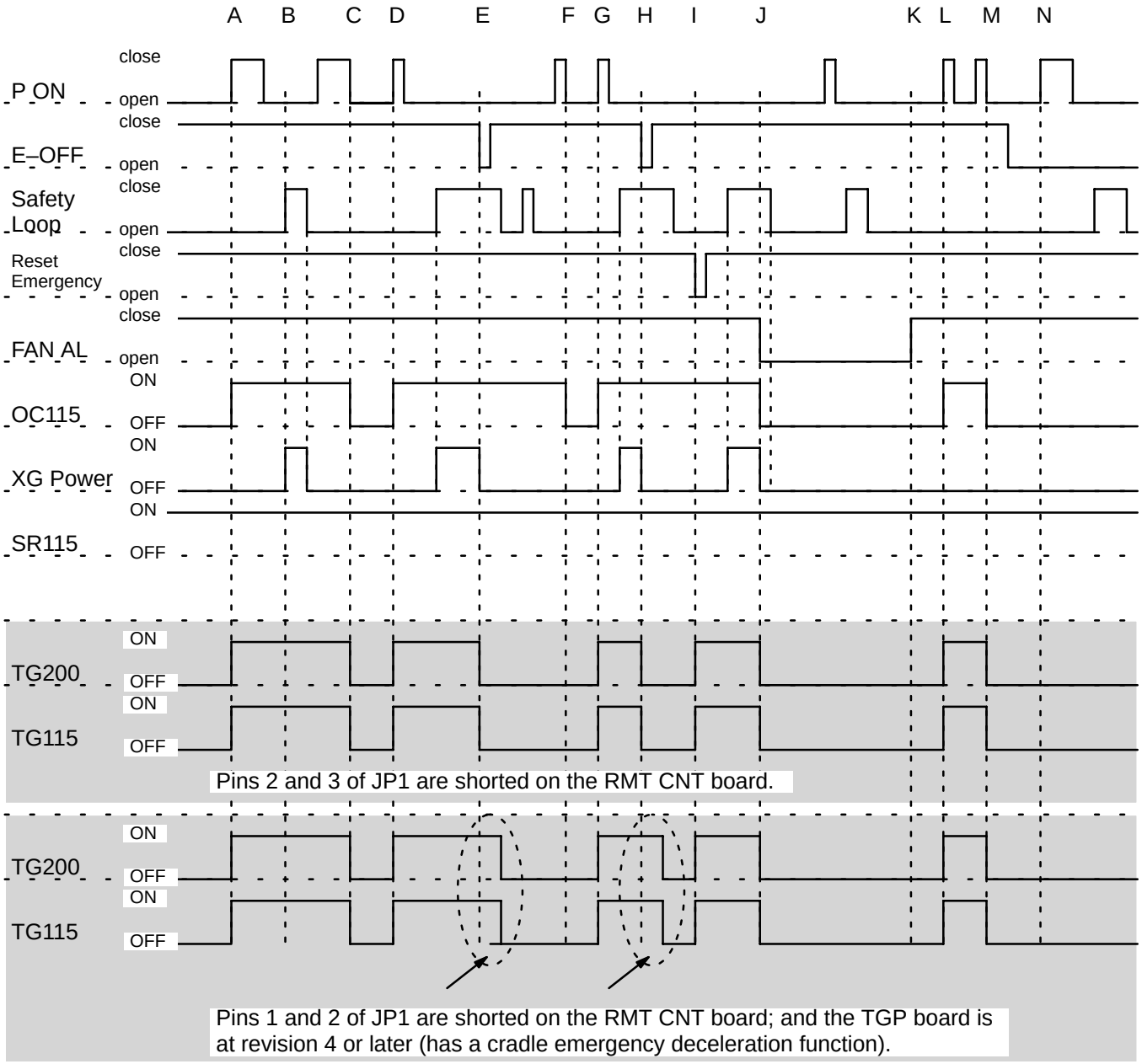
  If pins 1 and 2 of JP1 are shorted on the RMT CNT board and the TGP board is at revision 4 or later (has a cradle emergency deceleration function), ‘TG200’ and ‘TG115’ turn OFF 0.4 sec ~ 0.5 sec later after ‘E–OFF’ turns ‘open’; during this period, the cradle is decelerated to a halt.

- Timing I:
  When ‘Reset Emergency’ turns ‘open’, ‘TG200’ and ‘TG115’ are brought to ON.

- Timing J:
  When ‘FAN AL’ turns ‘open’, ‘XG Power’, ‘TG200’, ‘TG115’ and also ‘OC115’ all turn OFF.

2-2 POWER DISTRIBUTION SEQUENCE (continued)

Illustration 2–5 Power Distribution Sequence



Note

'Safety Loop' is always closed in normal conditions after the system is switched ON or reset; this means that 'XG Power' is always supplied to the gantry in normal conditions.

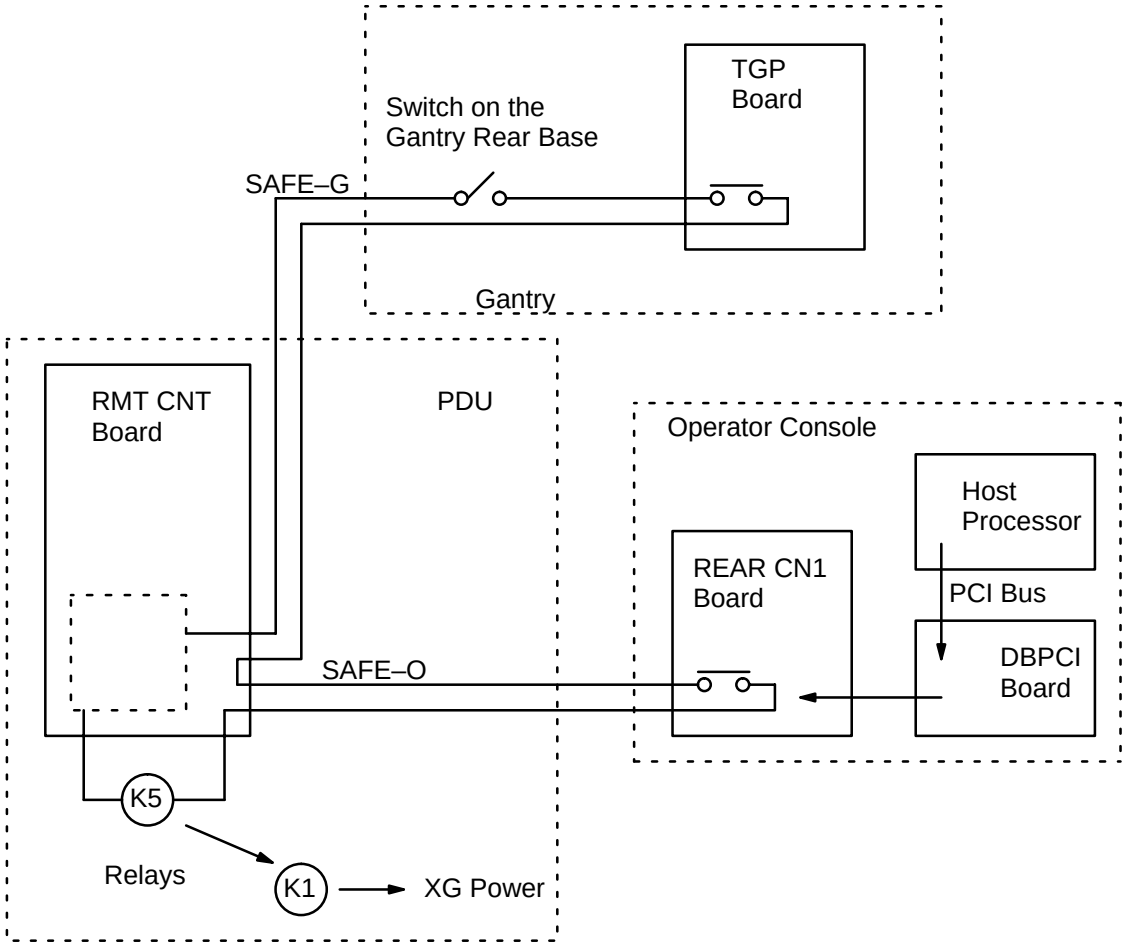
2-2 POWER DISTRIBUTION SEQUENCE (continued)

2-2-2 Safety Loop

Illustration 2–6 shows a diagram of the system safety loop.

As shown, components on the gantry rotational block are not involved in the safety loop.

Illustration 2–6 Safety Loop



2-2 POWER DISTRIBUTION SEQUENCE (continued)

Open of Safety Loop

The safety loop can be opened by any of the following:

- Switch equipped on the gantry rear base.
- Control by the TGP board:
  The TGP board opens the safety loop in any of the following cases:
  - When the TGP board receives from the OGP board a safety loop open demand due to an overtime of x–ray exposure.
  - When the TGP board detects abnormal communication with the OGP board or the operator console (host processor) during x–ray exposure.
- Control by the host processor (i.e., system software):
  The host processor opens the safety loop in any of the following cases:
  - When the host processor receives a safety loop open demand from the TGP board.
  - When the host processor detects an overtime of x–ray exposure.
  - When the host processor detects an extra scan (other than scans which the host processor instructed the TGP board to perform) performed.
- Signals such are ‘E–OFF’, ‘FAN AL’, etc.

SECTION 3 – SCAN OPERATION

3-1 WARM–UP SCANS

The system requires the 'Warm–up' scans to warm–up the x–ray tube just after power–on and prior to starting the first scan, or when more than three hours have elapsed since the last scan.
The warm–up scans also have to be performed before performing phantom calibration which updates the calibration files (CAL files), if more than three hours have elapsed since the last scan.

The following scans are performed during the warm–up scan sequence.

Table 3–1 Warm–up Scans

Scan	Scan Parameter	No. of Scans
for x–ray tube warming	Axial, 2.0 sec, 80 kV, 80 mA, Large Focus, 1 mm	(Until the anode heat level reaches 5.0%.)
	Axial, 2.0 sec, 120 kV, 100 mA, Large Focus, 1 mm	(Until the anode heat level reaches 13.0%.)
	Axial, 2.0 sec, 120 kV, 200 mA, Large Focus, 1 mm	(Until the anode heat level reaches 48.0%.)
for data collection	Axial, 50 FOV, 1.0 sec, 120 kV, 200 mA, Large Focus, 10 mm	1
	Axial, 25 FOV, 3.0 sec, 120 kV, 60 mA, Large Focus, 10 mm	1
	Axial, 25 FOV, 1.0 sec, 120 kV, 60 mA, Large Focus, 10 mm	1

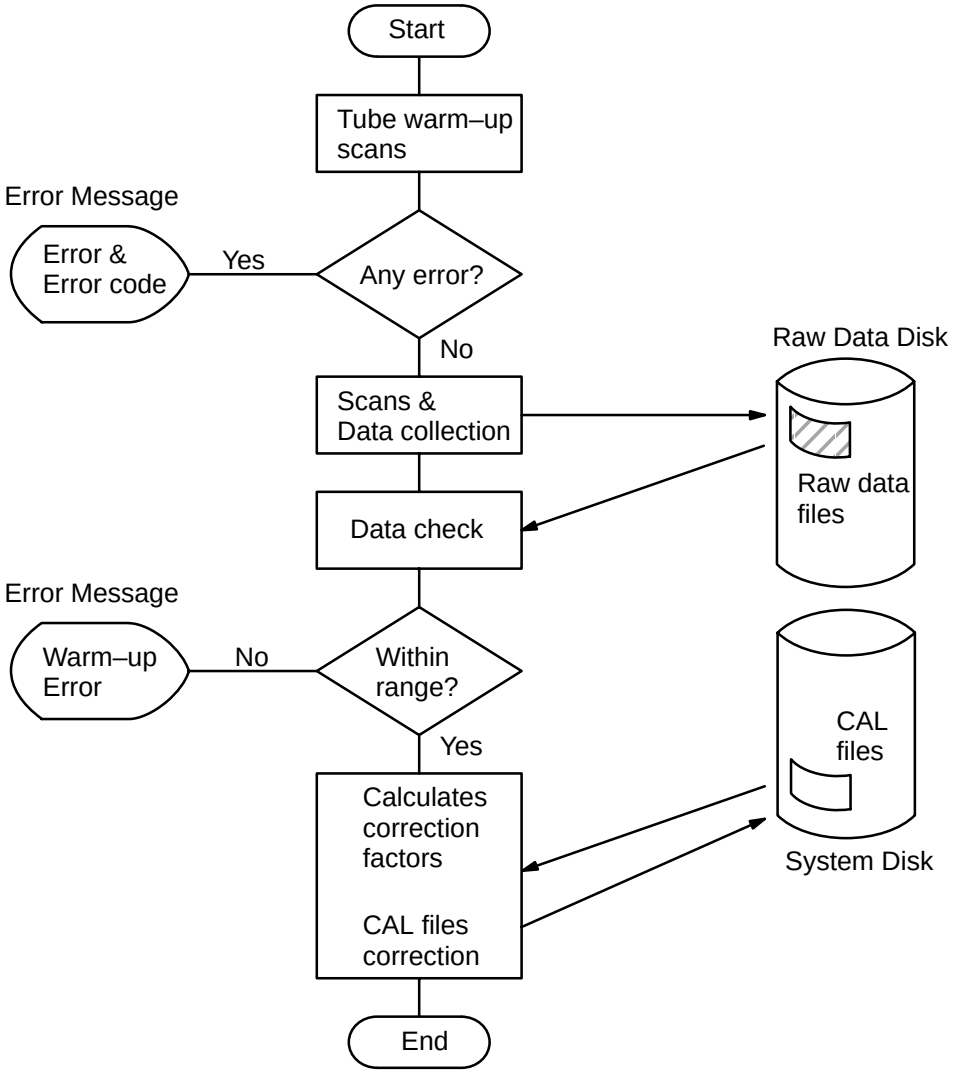
The first three series of scans warm–up the x–ray tube.

During the last three scans, data is collected to analyze it and update the CAL files:
The data is stored and whether the data falls within the specified range is checked. If data is out of range, the system reports a 'WARM–UP ERROR.' If data is within range, the system compares the data and the previous warm–up data and calculates correction factors for the CAL files, and updates the CAL files.

Illustration 3–1 shows the warm–up scan sequence.

3-1 WARM–UP SCANS (continued)

Illustration 3–1 Warm–up Sequence



3-2 AXIAL SCANS

Prior to the actual x–ray exposure, the system collects 64 views of offset data generated from the DAS. The offset data is used to correct actual x–ray data.

The system performs a full 360 deg. scan (clockwise direction only) during 0.7 (NP++), 0.8, 1.0, 1.5, 2.0, or 3.0 sec. These are called scan speeds or scan times, and not all of the them are available to all the systems; the available scan speeds or times vary according to system models or options installed on the systems.

During a scan, the system collects 972 views of data. A view period differs according to the scan speed. The following table shows this relation:

Scan Speed (sec)	View Period (μsec/view)
0.7 (NP++)	720
0.8	823
1.0	1029
1.5	1543
2.0	2058
3.0	3086

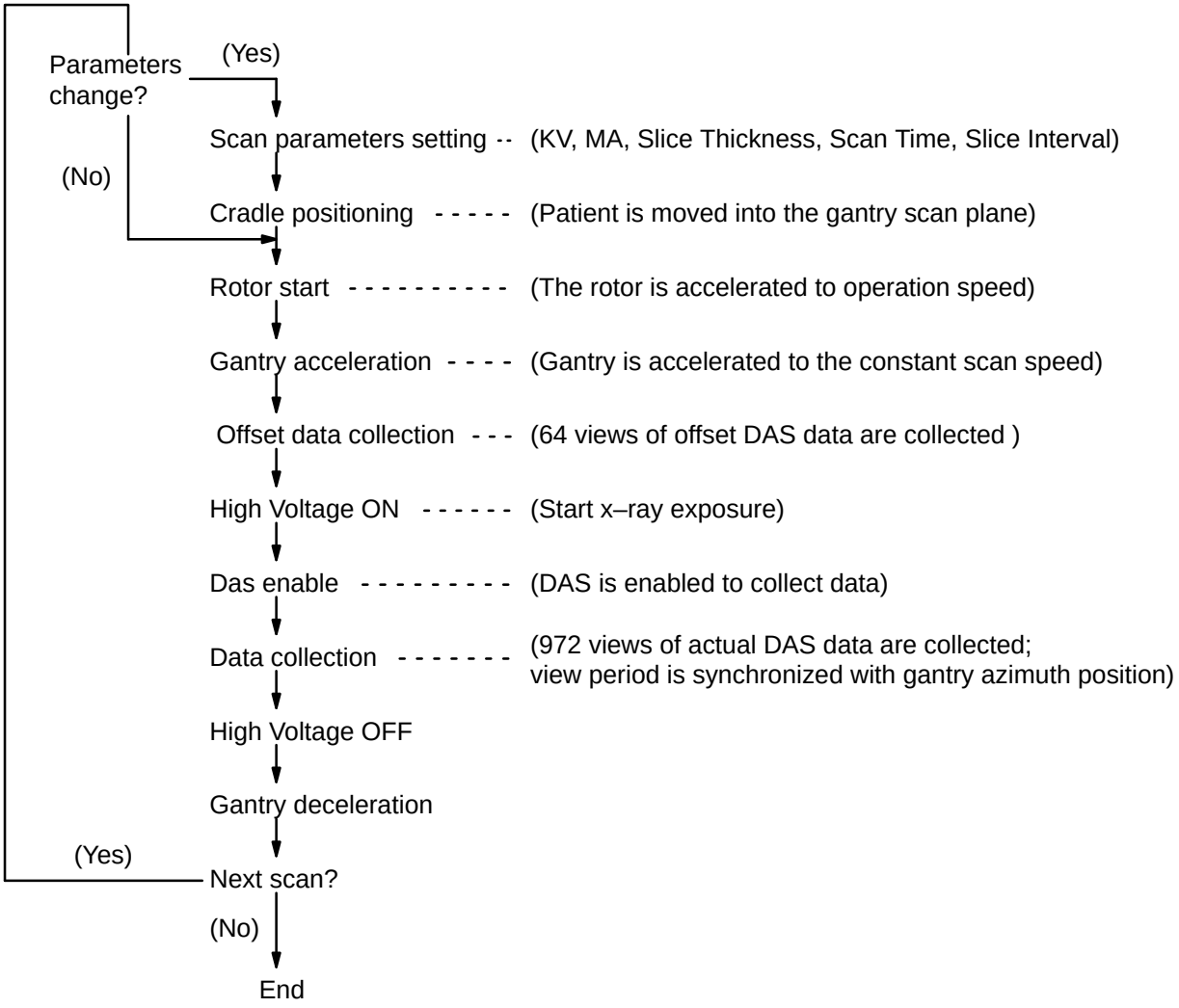
The view period is synchronized with the azimuth encoder pulse.

Axial scans are initiated from either 0 deg. or 180 deg. azimuth angle except for helical scans; during helical scans, scans can be initiated from any azimuth angle.
The system knows gantry azimuth position by azimuth encoder pulse counts and the Gantry Pulse which indicates that the gantry azimuth is at this moment at 0 deg., i.e., home position).

Illustration 3–2 shows the axial scan sequence.

3-2 AXIAL SCANS (continued)

Illustration 3–2 Axial Scan Sequence



3-3 SCOUT SCANS

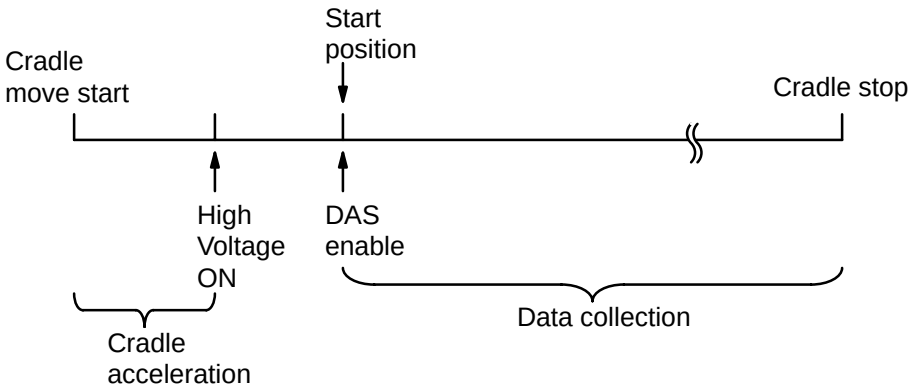
Prior to the actual x–ray exposure, the system collects 64 views of offset data generated from the DAS. The offset data is used to correct actual x–ray data.

The system advances the cradle and collects data from 793 (or 717 for NP) active channels. The cradle speed is 75 mm/sec, and data collection timing is synchronized with the cradle encoder pulse.

Illustration 3–3 shows the scout scan sequence.

Illustration 3–3 Scout Scan Sequence

Scan parameters setting -- (KV, MA, Scan Range)
↓
Cradle positioning - - - - - (Cradle is moved to the Start + 20 mm position)
↓
Rotor start - - - - - - - - - - (The rotor is accelerated to operation speed)
↓
Offset data collection - - - (64 views of offset DAS data are collected)
↓
Cradle acceleration - - - - (Cradle is accelerated to the constant scan speed)
↓
High Voltage ON - - - - - - (Start x–ray exposure)
↓
Das enable - - - - - - - - - (DAS is enabled to collect data)
↓
Data collection - - - - - - - (Actual DAS data are collected;
view period is synchronized with cradle position)
↓
High Voltage OFF
↓
Cradle Stop



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OPERATOR CONSOLE

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SECTION 1 – GENERAL DESCRIPTION

1-1 OVERVIEW

The information processing system (operator console) is based on the PCI (Peripheral Component Interconnect) bus architecture.

The host processor of the operator console is a Unix workstation, which is on the market.
(Workstation: The physical hardware that contains the CPU and graphics boards, a system disk, and a power supply. You connect it to a monitor, keyboard, and mouse to configure a working system.)
The model type of this workstation is called 'O2.'

Illustration 1–1 shows a block diagram of the operator console of this CT system.

O2 System Software

'O2 System Software' is the standard IRIX operating system software for the O2 and Silicon Graphics tools that come on the system disk and on the CD–ROM that you use in the event of a system crash.
(IRIX: Silicon Graphics's version of the UNIX operating system)

PCI Bus

'PCI' stands for Peripheral Component Interconnect – a bus specification. The PCI bus is a high–performance local bus used to connect peripherals to memory and a microprocessor. A wide range of vendors make devices that plug into the PCI bus.

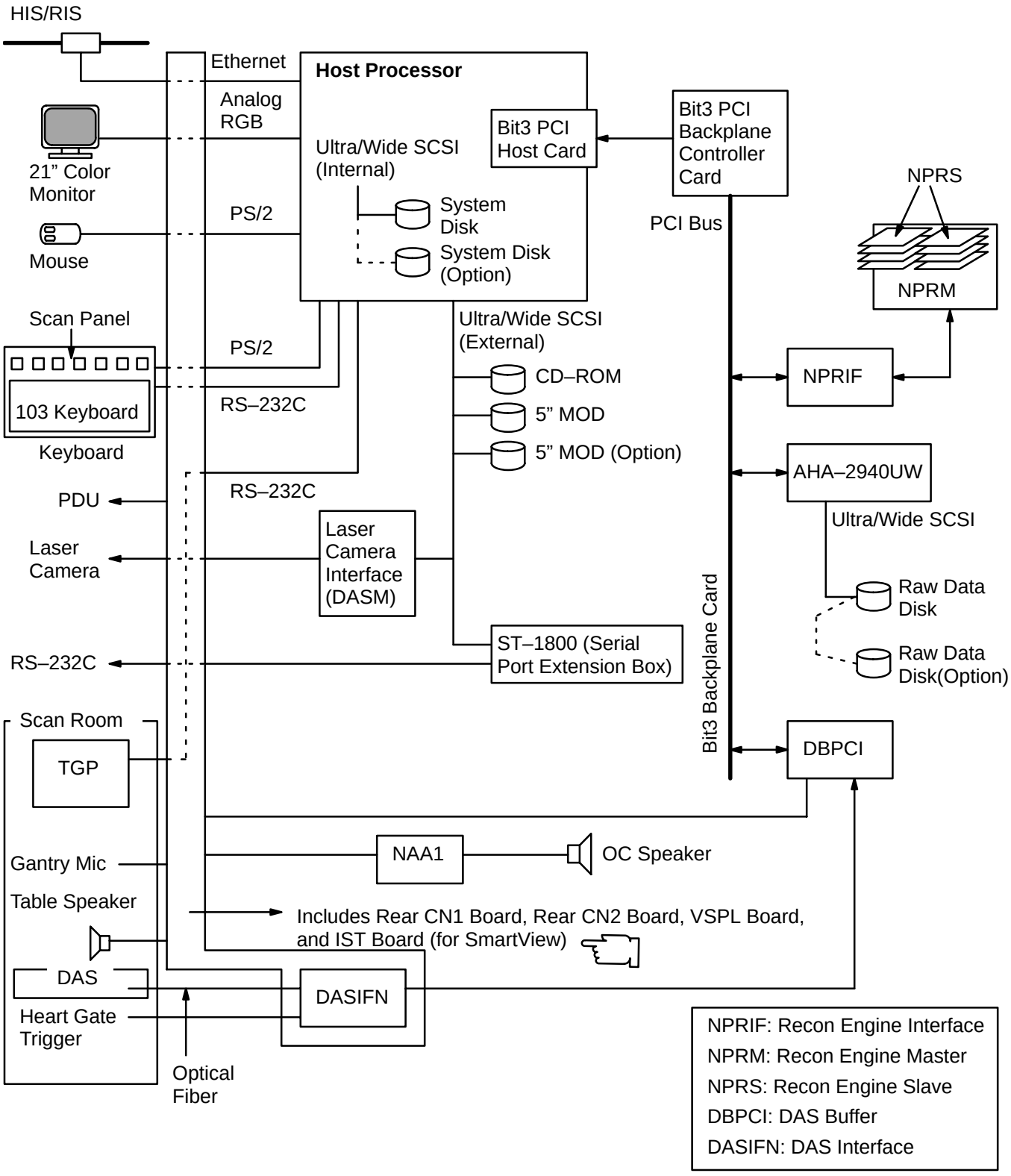
The PCI bus can be operated at its intended high–performance by using DMA transfers.

To perform DMA transfers with the PCI bus, a DMA controller should be equipped on the connected peripheral.

Address Map

For a PCI bus based computer system, memory address mapping and I/O address mapping of PCI devices are determined during Configuration Cycle which the host processor generates when the system is powered on. Each of the PCI devices requests its required address space size from the host processor during the cycle.
The PCI devices also (such are DBPCI, NPRIF, others) within this operator console are relocatable in the PCI address space. This means that address mappings of the PCI devices are not fixed. The physical addresses assigned by the host processor can be known by reading a set value on a base address register within configuration registers of each PCI device. (With a VME bus, base addresses are determined by dip switches.)

Illustration 1–1 Operator Console Block Diagram



1-2 MAIN COMPONENT DESCRIPTION

Host Processor

The host computer performs all of the following operations:

User interface
Image processings/display (all processings except recon)
Communication
Database control
Raw data/image data flow control
Image storage
Scan/recon control

System Disk (Ultra/Wide SCSI; within the Host Processor)

The host processor includes a hard disk drive which is used as the system disk. This system disk mainly stores the followings:
System and application software
Images
Calibration files
System parameters

- Capacity: 4 GB

  Image Storage: 6000 images (take up 3 GB (1 image/0.5 MB))
  (The remained 1 GB storage is used for System software/swapping space + Application software)

NPR (NP/NP+ Recon Engine)

This is a unit for performing high–speed recon operations.

This unit consists of the following three kinds of circuit boards:

- **NPRIF (NPR Interface):**
  Performs interfaces between the PCI bus and the NPRM.

- **NPRM (NPR Master):**
  Includes one master DSP (Digital Signal Processor), main memory called Global Memory 0, others.

- **NPRS (NPR Slave):**
  Includes two slave DSP's which perform arithmetic operations under the NPRM control.

The NPRS is a piggyback board equipped on the NPRM, and up to eight NPRS boards can be equipped on the NPRM (i.e., up to 16 slave DSP's can be equipped).

The NPRIF only is connected to a PCI slot. The NPRIF and NPRM are connected by cables.

1-2 MAIN COMPONENT DESCRIPTION (continued)

DBPCI (DAS Buffer for PCI Bus)

This is a circuit board, serving as a ring buffer whose capacity is 4 MB. This buffer temporarily stores DAS data.
This board also includes control registers for the OC keyboard, safety loop, others.

DASIFN (DAS Interface for NP/NP+)

This is a circuit board which converts raw data sent from the gantry in optical serial signals into electric parallel signals.
During conversion, this board performs transfer error corrections.
This board also includes one channel for receiving Heart Gate Trigger inputs.

PCI Expansion Unit

Consists of PCI Host Card, PCI Backplane Controller Card, PCI Backplane Card.
Increases the number of slots which are connected to the PCI bus of the host processor.
Circuit boards for scan/recon are connected to these slots (NPRIF, DBPCI, AHA–2940UW).

REAR CN1

This is a circuit board which mainly has two functions: Signal filtering and Audio control.
This board is connected to OC external components such are keyboard, TGP board on the gantry, or Power Distribution Unit (PDU), and is also connected to OC internal components such are DBPCI board, NAA1 board, or others.

Raw Data Disk (Ultra/Wide SCSI)

This is a high–speed hard disk drive for storing raw data.

- Capacity: 2 GB

  Raw Data Storage: 450 raw data files
  (70% of the disk space is used for raw data storage; 30 % of it is not used, because of low read/write rate)

  For NP++, the capacity is 4 GB.

Archive Equipment (MOD)

MOD is used for archiving images/raw data.
MOD is also used during system software installation to temporarily store data.

- Capacity: 2.3 GB, Density: 4x (Hitachi/Sony MOD)

  Images: DICOM format
  Raw data: YMS format as Unix files (Includes Cal files, others)

CD–ROM Drive

Used for system software loading.

1-3 OPERATIONAL DESCRIPTION

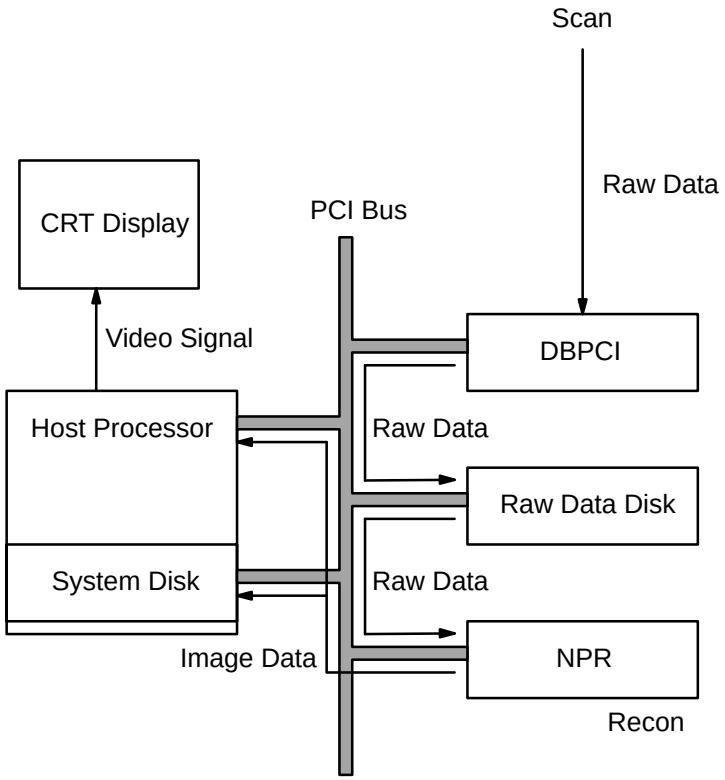
Scan Data Main Flow

Illustration 1–2 shows:

Raw data acquired during scans is first buffered by DBPCI;
The raw data is then stored to a hard disk drive which is a high–speed type and exclusively used for raw data storage;
The raw data is then transferred to the NPR where recon processing is performed;
The reconstructed images are then read by the host processor which converts the image data to video signal, as well as stores the image data to the system disk, which also stores system software.

As shown, raw data and image data are mainly transferred over the PCI bus.

Illustration 1–2 Scan Data Main Flow



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SECTION 2 – HOST PROCESSOR

2-1 OVERVIEW

The host processor is a Unix workstation; its product name is ‘O2.’

The host processor is the central unit within the operator console, performing various operations such are described below:

- Controls data transfer between data storage units and memory devices located on NPR, etc.
- Controls the entire scan sequence; it sends necessary instructions to relevant processors and devices, and receives status information from those processors and devices.
- Controls the NPR (NP Recon Engine).
- Performs graphics operations.

The host processor includes a DC power supply (175 watts); it requires AC 115 V power.

2-1 OVERVIEW (continued)

Table 2–1 shows main specifications of the host processor.

Table 2–1 Host Processor Specifications

Component		Specification
Central Processor	Model	MIPS R5000SC
	Operating Frequency	200 MHz
	Cache Memory	32 kB data/32 kB instruction primary cache 1 MB secondary cache
Main Memory	Capacity (standard)	64 MB (32 MB DIMM X 2)
	Type	Synchronous DRAM, 100 MHz, 4 banks, 288–bit wide
	Upgrade	up to 256 MB with 16 Mbit SDRAM up to 1 GB with 64 Mbit SDRAM
Hard Disk Drive (System Disk)	Capacity	4 GB (5400 rpm)
CD–ROM	Type	12 X
Graphics	Resolution	1280 x 1024 pixels 75.03 Hz Frame Rate 1024 x 768, 800 x 600, 640 x 480 also supported
	Frame Buffer Formats	32 + 32 bit FB (32 + 32 double buffered) 32 bit FB (16 + 16 double buffered) 16 bit FB (8 + 8 double buffered) 8 bit overlay
	Video Signal	Horizontal Statistics Horizontal Front Porch : 118.52 nsec ; 16 pixels Horizontal Back Porch : 1.84 µsec ; 248 pixels Horizontal Sync : 1.07 µsec ; 144 pixels Horizontal Active : 9.48 µsec ; 1280 pixels Horizontal Line Rate : 79.98 KLines/sec First Field Statistics Vertical Front Porch : 12.50 µsec ; 1.00 lines Vertical Back Porch : 475.14 µsec ; 38.00 lines Vertical Sync : 37.51 µsec ; 3.00 lines Vertical Active : 12.80 msec ; 1024.00 lines Vertical Sync Pulse : 38.58 µsec ; 3.09 lines Pixel Clock : 135.00 MHz

2-1 OVERVIEW (continued)

Table 2–1 Host Processor Specifications (continued)

Component		Specification
Built–in I/O (Input/Output)	–	PC (PS/2) compatible keyboard and mouse 2 x Ultra Fast/Wide SCSI single–ended, 1 internal, 1 external (40 MB/sec each) 2 x Serial 460 kbps (DB–9) 1284 Parallel (C miniature) 10BaseT/100BaseTX Ethernet standard (RJ–45)
Audio	–	Analog stereo input/output
Expansion Slot	–	One half–length, 64–bit PCI slot (10 W)
Operating System	–	IRIX 6.3 with XFS or later

2-2 BUILT–IN I/O (INPUT/OUTPUT) DESCRIPTION

The host processor has input/output ports for the following:

Display

Analog RGB signals are output from this port.

Keyboard/Mouse

A PS/2 keyboard and a mouse are connected these ports, respectively.

10BaseT/100BaseTX Ethernet

A diagnostic console, an independent console, or an HIS/RIS is connected to this port.
DICOM compatible; the operator console can send (push) images to those devices using DICOM protocols at a 10 Mbits/sec maximum (the transfer speed varies according to receiver models, the size of transfer data, protocols, etc.).

Ultra/Wide SCSI (Internal – This port is provided within the host processor)

The O2 host processor includes a hard disk drive. This drive is used as the system disk, and is connected to this port. The disk is also used for storing images.

Ultra/Wide SCSI (External)

Since this port is a wide SCSI, the data bus of this port is 16–bit wide. However, within this OC, devices which handle eight–bit data such are CD–ROM drive, MOD drive, or Camera Interface are connected to this port in daisy chain.

Serial Port (RS–232C)

Provides two serial ports; one is used for communication with the TGP board, and the other is used for communication with scan keys (on the keyboard).

Audio

Provides audio input/output ports. The host processor can record audio signals from a microphone or other sources, and can play recorded audio data. This function is used for Autovoice.

PCI Bus Slot

The host processor is equipped with one PCI slot.
In order to expand the PCI bus, a ‘PCI Host Card’ is connected to this slot. The ‘PCI Host Card’ is a component of the PCI Expansion Unit.

SECTION 3 – CONNECTOR BOARDS

3-1 CONNECTOR BOARDS

All the signal cables connected between the operator console (OC) and subsystems/components outside the OC run through these connector boards.

The connector boards mainly include filters for each signal line to improve the EMC (Electro–Magnetic Compatibility) performance of the OC. The REAR CN1 board also includes an audio mixer, relay for the safety loop, and others.

3-2 REAR CN1 BOARD

Illustration 3–1 shows a block diagram of the REAR CN1 board.

The REAR CN1 board is connected to a slot of the connector box of the OC, and as shown in Illustration 3–1, the board is connected to OC external components such are the keyboard, TGP board on the gantry, or the Power Distribution Unit (PDU), and is connected to OC internal components such are DBPCI board, NAA1 board, or others.

The board functionally consists of the following two blocks:

- Filter Block
- Audio Mixer Block

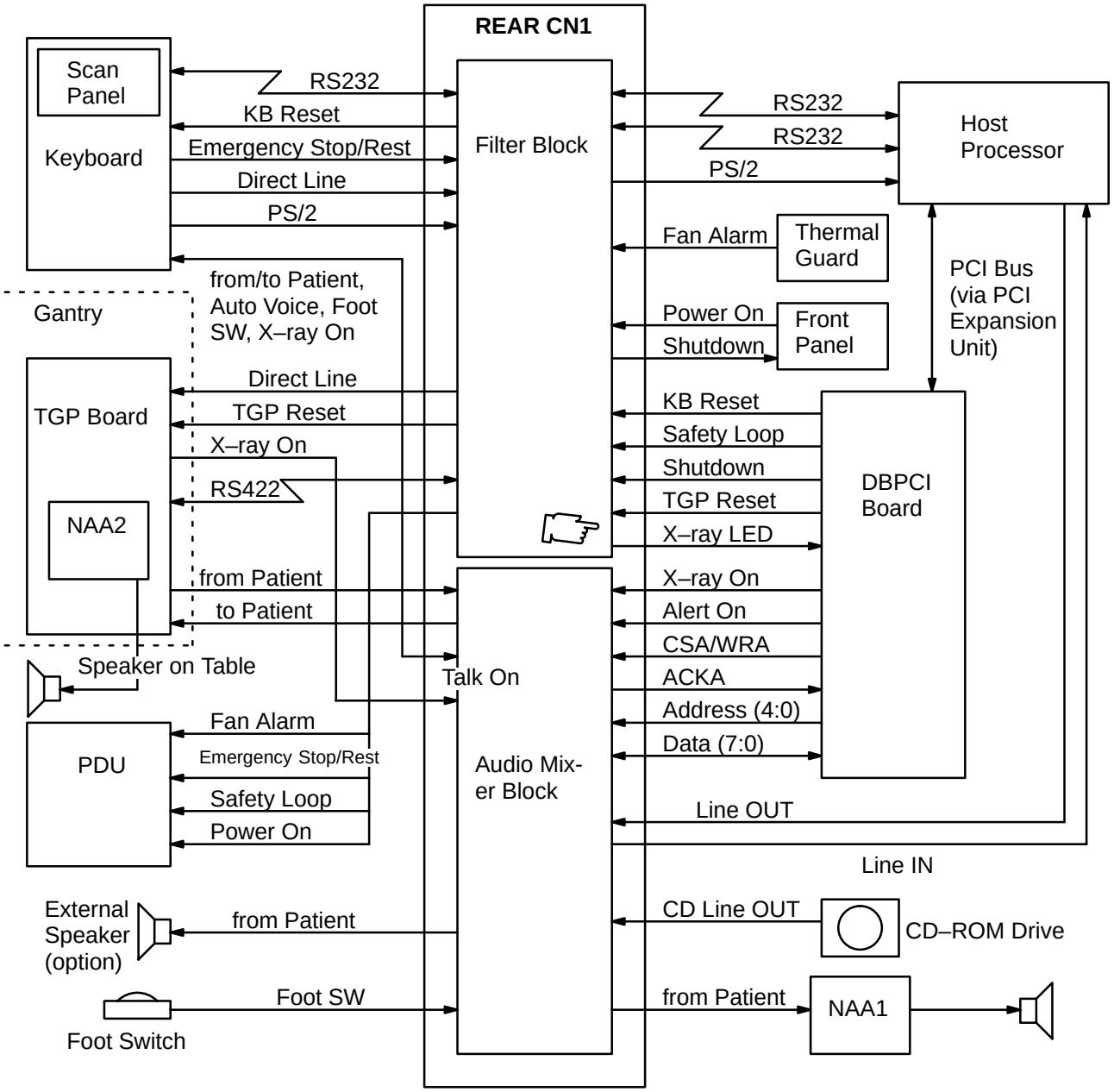
3-2-1 Filter Block

As shown in Illustration 3–1, this block includes the following interface circuits:

- **Keyboard Interface:**
  Mainly interfaces between the keyboard (including the scan buttons) and the host processor.
- **TGP Interface:**
  Mainly interfaces RS232/RS422 communications and Direct Lines between the TGP board located on the gantry and the host processor or keyboard.
- **PDU Interface:**
  Mainly interfaces Power On/Off, Emergency, Safety Loop, or other signals between the Power Distribution Unit (PDU) and the keyboard or the FRONT PNL board of the OC.

3-2 REAR CN1 BOARD (continued)

Illustration 3–1 REAR CN1 Block Diagram



3-2 REAR CN1 BOARD (continued)

3-2-2 Audio Mixer Block

The audio mixer block of the REAR CN1 board Includes registers for audio function, and also includes an audio amplifier for headphones or external speakers (which are not the OC speaker which is driven by the NAA1 board).

See Illustration 3–2.
As shown, audio signals from several sources are mixed in this block.

- Audio Input Sources:
  - Microphone on the gantry (Intercom: From Patient)
  - Microphone on the OC keyboard (Intercom: To Patient)
  - Audio output on the host processor (Auto Voice play)
  - Audio output on the CD–ROM drive (BGM, or other)
  - Synthesized sounds on the REAR CN1 board (X–ray On, Alert)
    These are generated using a programmable timer which is controlled by software.
- Audio Output Destinations:
  - Speaker on the gantry
  - Speaker on the OC
  - Audio input on the host processor (for recording Auto Voice messages)

3-2 REAR CN1 BOARD (continued)

Audio Input Switch

As shown in Illustration 3–2, analog switches are used to switch audio input sources, and are controlled by the ‘Talk On’ button on the keyboard or a foot switch connected to the keyboard.

- An intercom function is provided between the OC room and the gantry room. The ‘Talk On’ button on the keyboard switches communication direction, as described below:
  - While ‘Talk On’ is pressed, communication of “OC room → gantry room” is enabled; and both of Auto Voice (both in the OC room and the gantry room) and sound from the CD–ROM drive (both in the OC room and the gantry room) are disabled.
  - While ‘Talk On’ is released, communication of “gantry room → OC room” is enabled.

  If a foot switch is provided, this also serves as the ‘Talk On’ button.
- The X–ray On sound and alert sounds in the OC room are always enabled, even when ‘Talk On’ is pressed.
- Auto Voice messages can be recorded by using the microphone equipped on the keyboard while pressing the ‘Talk On’ button.
  While Auto Voice is being played, communication of “gantry room → OC room” can be disabled. This prevents Auto Voice sound degradation on the OC side, because: Auto Voice is played both in the OC room and the gantry room. If communication of “gantry room → OC room” is enabled, the Auto Voice messages are doubled on the OC side, which degrades the sounds.

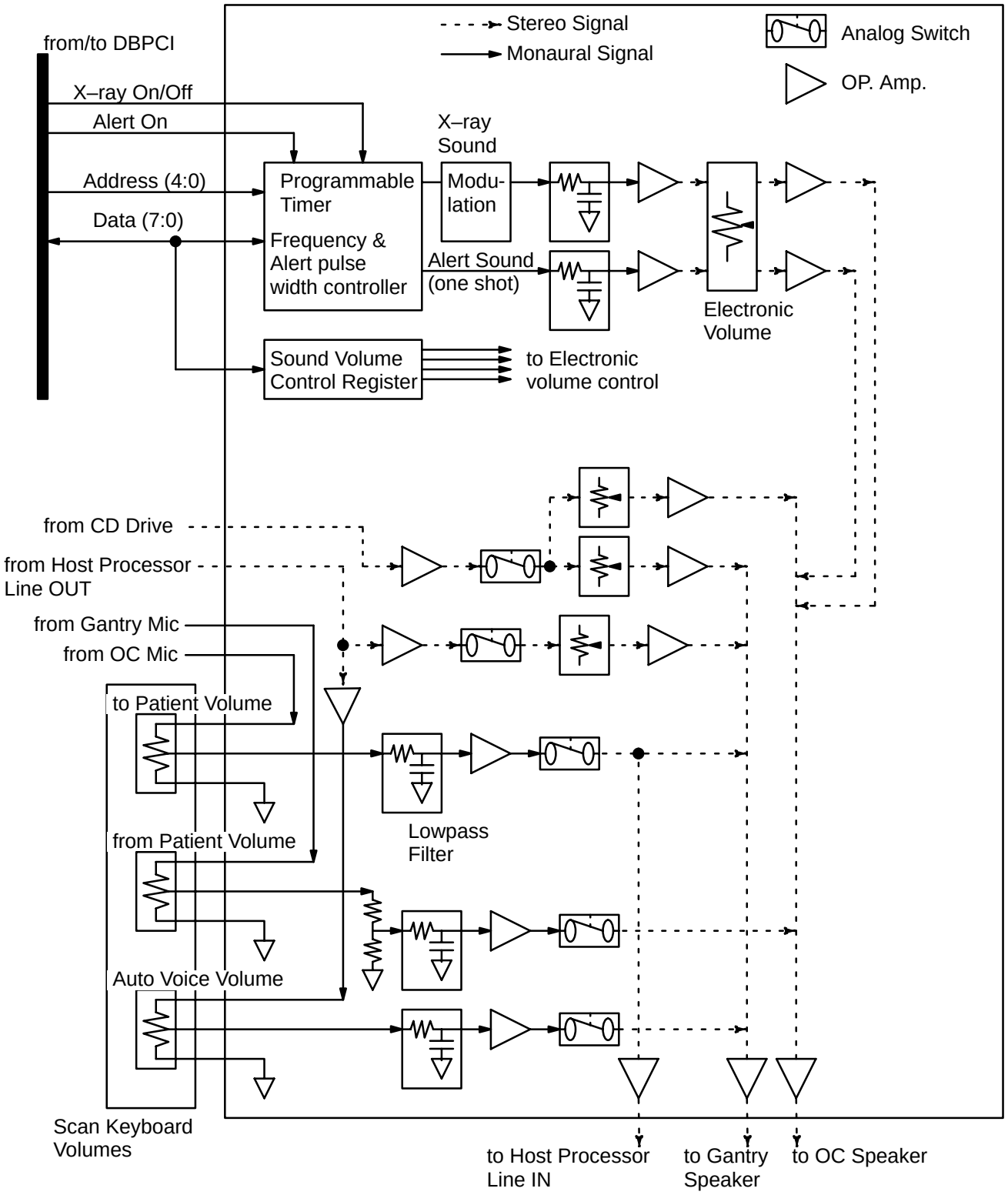
Volume Control

The following two kinds of volume control are provided.

- The following can be adjusted with the manual **volumes on the keyboard**:
  - Volume of communication of “OC room → gantry room” (through the keyboard microphone)
  - Recording level of Auto Voice messages (through the keyboard microphone)
  - Auto Voice volume in the gantry room
  - Volume of communication of “gantry room → OC room” (through the gantry microphone)
- The **electronic volumes** are controlled by software, controlling the following:
  - Auto Voice volume in the OC room
  - Sound volume from the CD–ROM drive both in the gantry room and the OC room
  - Alert sounds in the OC room
  - X–ray On sound in the OC room

3-2 REAR CN1 BOARD (continued)

Illustration 3–2 Audio Mixer Block



3-2 REAR CN1 BOARD (continued)

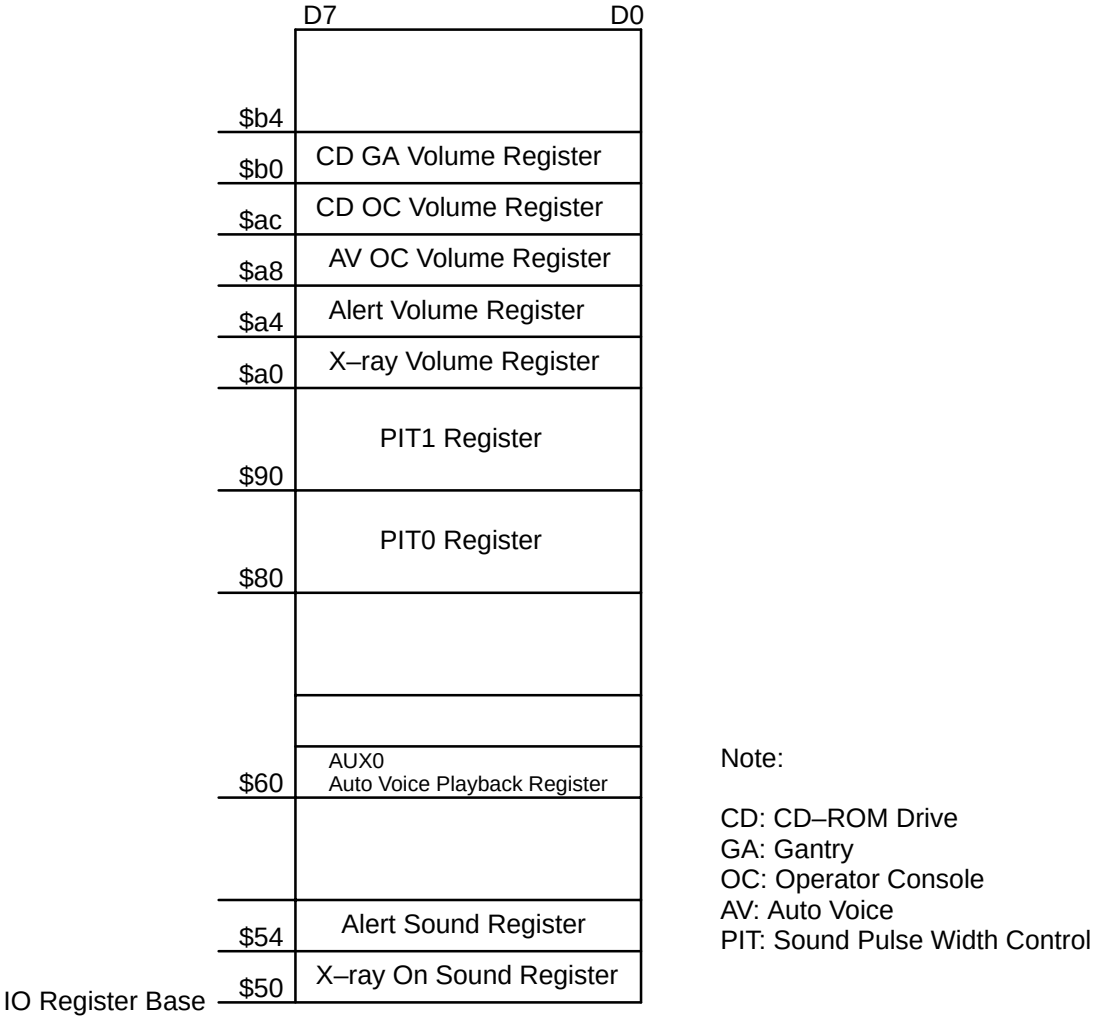
Audio Register Address Map

Illustration 3–3 shows an address map of audio control registers.
The addresses shown are mapped at an area within the DBPCI Input/Output address space of the host processor.

Registers mapped within the I/O register bases $50 ~ $7F are located on the DBPCI board. These are controlled by the host processor, and control signals only are sent from DBPCI to the REAR CN1 board.

Registers mapped within the I/O register bases $80 ~ $FF are located on the REAR CN1 board. These registers and the DBPCI board are connected via a dedicated bus.

Illustration 3–3 Audio Register Address Map



Note:

CD: CD–ROM Drive
GA: Gantry
OC: Operator Console
AV: Auto Voice
PIT: Sound Pulse Width Control

SECTION 4 – OTHER OC COMPONENTS

4-1 KEYBOARD, MOUSE

The keyboard used for this operator console integrates the following components:

- **103 Keyboard, Mouse:**
  This 103 keyboard and the mouse have a PS/2 interface for connecting themselves to the host processor.
- **Scan Keys, Microphone:**
  Keys used for scanning, and a microphone used for an intercom are incorporated into the keyboard. These keys are connected to the host processor via RS–232C.

The keyboard and the TGP board are connected by ‘Direct Lines’ for the remote cradle and gantry tilt control.

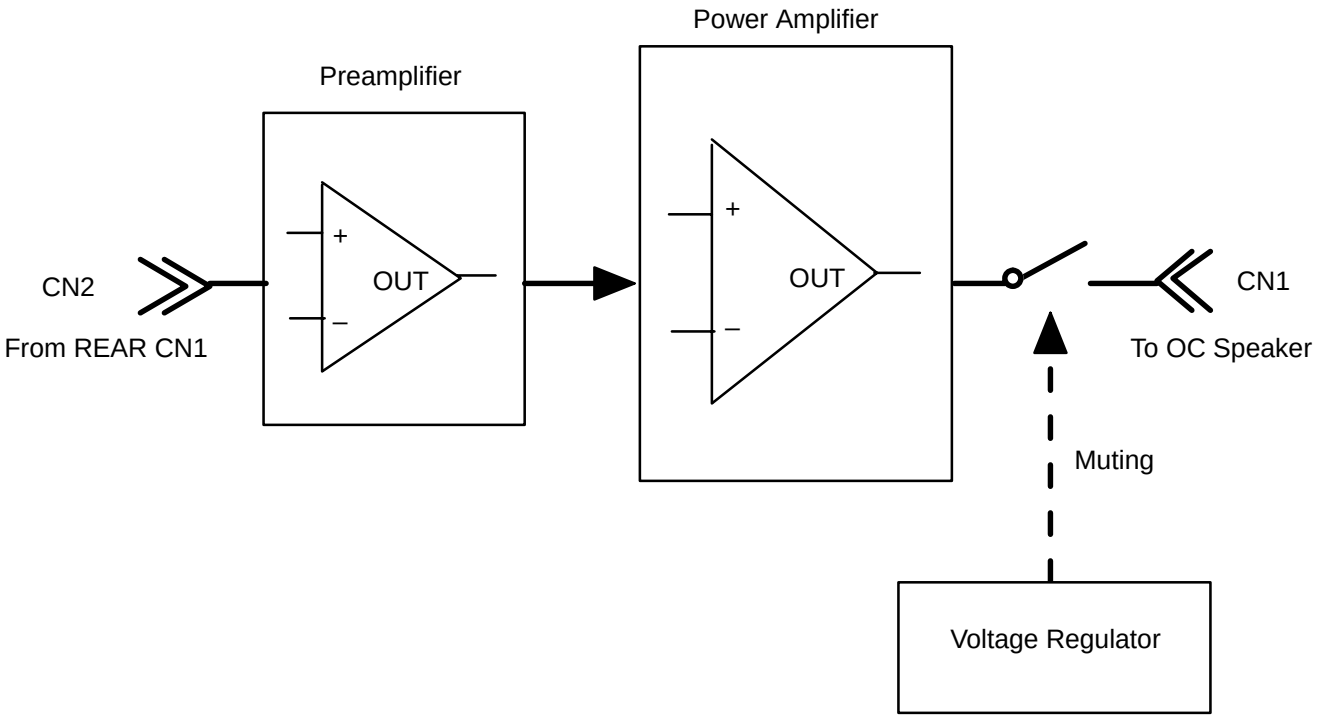
4-2 CRT DISPLAY

- 21” color monitor
- The resolution used for the CRT Display is 1280 x 1024 matrix.
  The refresh rate used is 75 Hz.

4-3 NAA1 (NP/NP+ AUDIO AMPLIFIER 1)

This is an amplifier board for the OC speaker. See the following block diagram.

Illustration 4–1 NAA1 Block Diagram



4-4 PCI EXPANSION UNIT

The host processor only provides one PCI slot. This unit expands this one slot to seven slots available. This unit consists of the following three boards (designed by Bit3):

PCI Host Card
PCI Backplane Controller Card
PCI Backplane Card

The main devices on these boards are PCI–PCI Bridge chips, which expand the number of slots in stages.

Illustration 4–2 shows a block diagram of the PCI Expansion Unit.

Table 4–1 describes installed circuit boards at those slots which are made available by the PCI Expansion Unit.

Table 4–1 PCI Slot Board

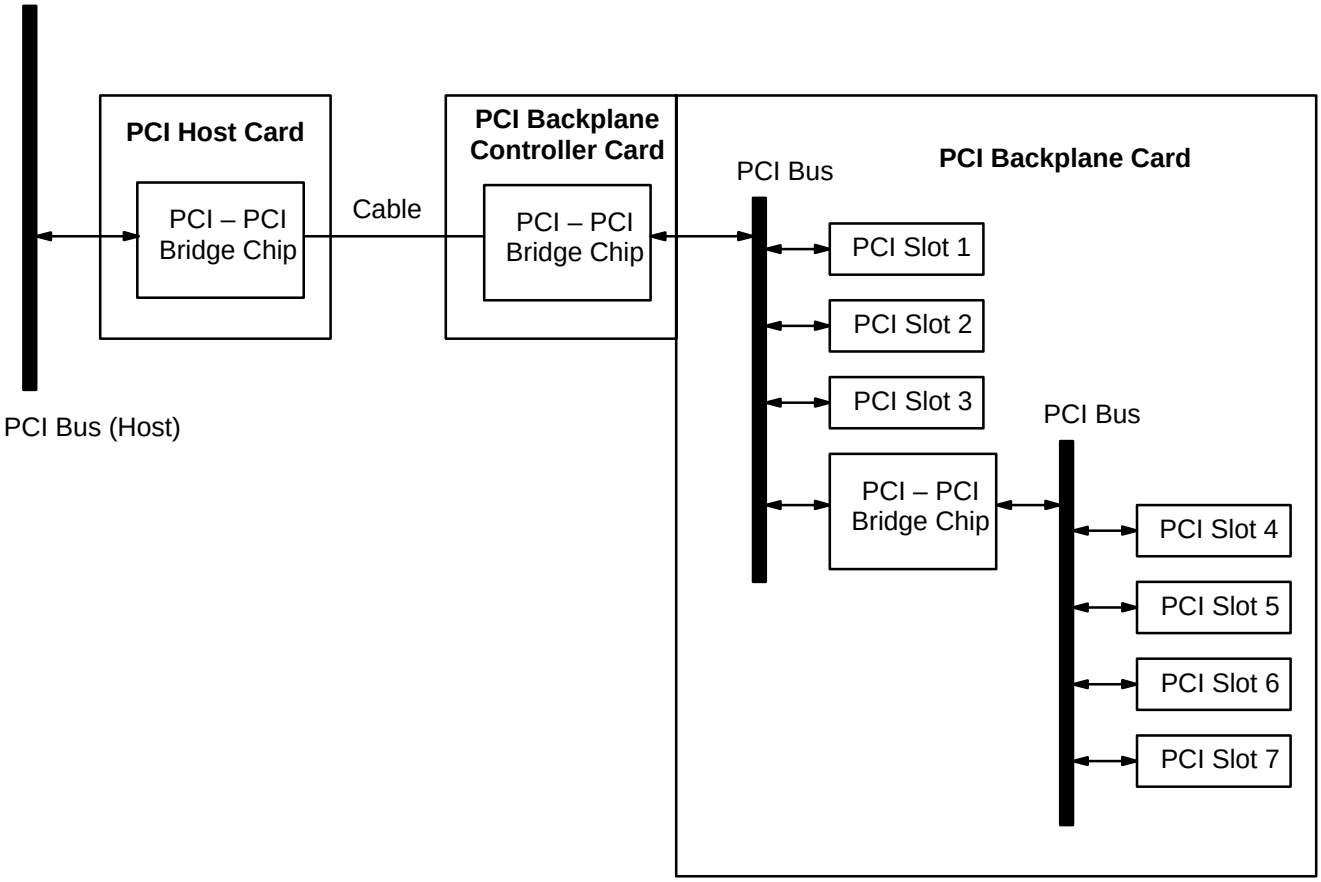
Slot	Board
Slot 1	NPRIF
Slot 2	DBPCI
Slot 3	(space)
Slot 4	AHA–2940UW
Slot 5	(space)
Slot 6	(space)
Slot 7	(space)

AHA–2940UW Card

This is a SCSI card of Adaptec. To this card, up to two hard disk drives can be connected for on–the–fly (high speed) raw data storage.

4-4 PCI EXPANSION UNIT (continued)

Illustration 4–2 PCI Expansion Unit



4-5 ST–1800 (SERIAL PORT EXTENSION BOX)

The host processor only provides two serial ports. To increase the number of available serial ports, the ST–1800 unit is used.

See Illustration 1–1 for the connection of the ST1800 unit within the operator console.
The unit is connected to the ultra/wide SCSI port of the host processor, and provides four serial ports available.
The serial ports may be used for connection with an InSite modem, a trackball, etc.

TABLE/GANTRY

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SECTION 1 – GENERAL DESCRIPTION

1-1 INTRODUCTION

The TGP (Table Gantry Processor) board is the main controller of the Table/Gantry subsystem. The TGP board receives command from the Operator Console and sends control commands to Table, Stationary Gantry and Rotationary Gantry including OGP (On Gantry Processor), DAS and X–ray Generator. Although the DAS/Detector and X–ray Generator are in the Gantry, they are not explained in this subsystem.

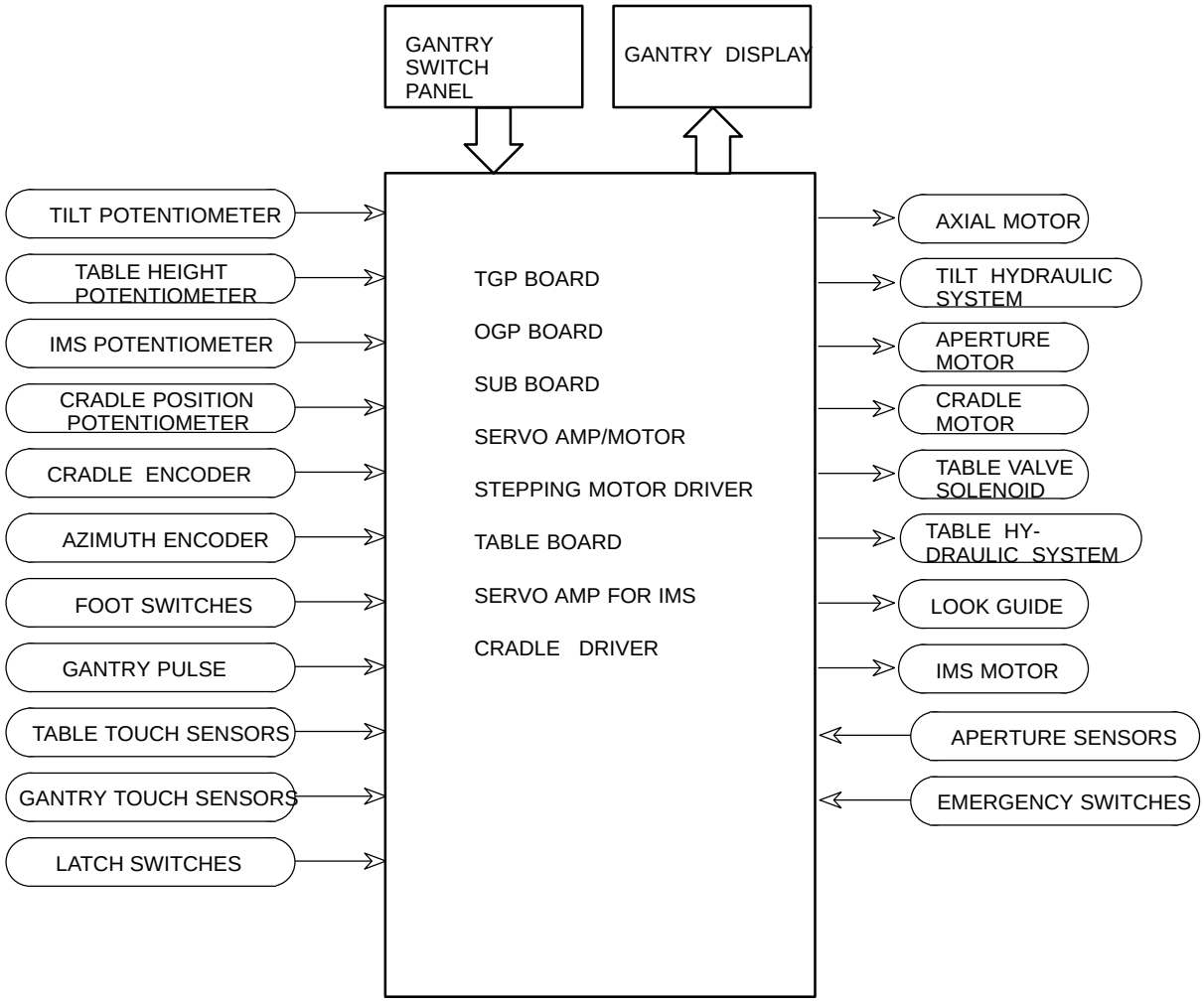
The Table/Gangry consists of the following components:

- TGP board
- OGP board
- SUB board
- Table board
- Servo Amp/Servo Motor
- Gantry Display
- Gantry Switch
- Collimator
- Positioning Light
- Hydraulic System (Gantry Tilt and Table elevation)
- Touch Sensors
- Cradle drive system
- IMS (Intermediate Support)

1-2 COMPONENTS INTERCONNECTION

The illustration 1–1 shows the components of the Table/Gantry.

Illustration 1–1 Table/Gantry



1-3 SPECIFICATIONS

The specifications of the Table/Gantry is as follows:

Gantry Rotation Speed

0.7 (NP++), 0.8, 1, 1.5, 2, 3 sec/rot.

Tilt Angle

30° ± 0.5°

Tilt Speed

BWD 30° ~ FWD 30° : 60 ± 6 sec

Table Height

400 ~ 950 mm

UP/Down Speed

From 400 mm to 950 mm height: 30 sec –5 sec +10 sec.

Cradle Speed

Slow 20 mm/sec
Fast 100 mm/sec
Scout 75 mm/sec
Home 100 mm/sec

IMS Speed

50 mm/sec

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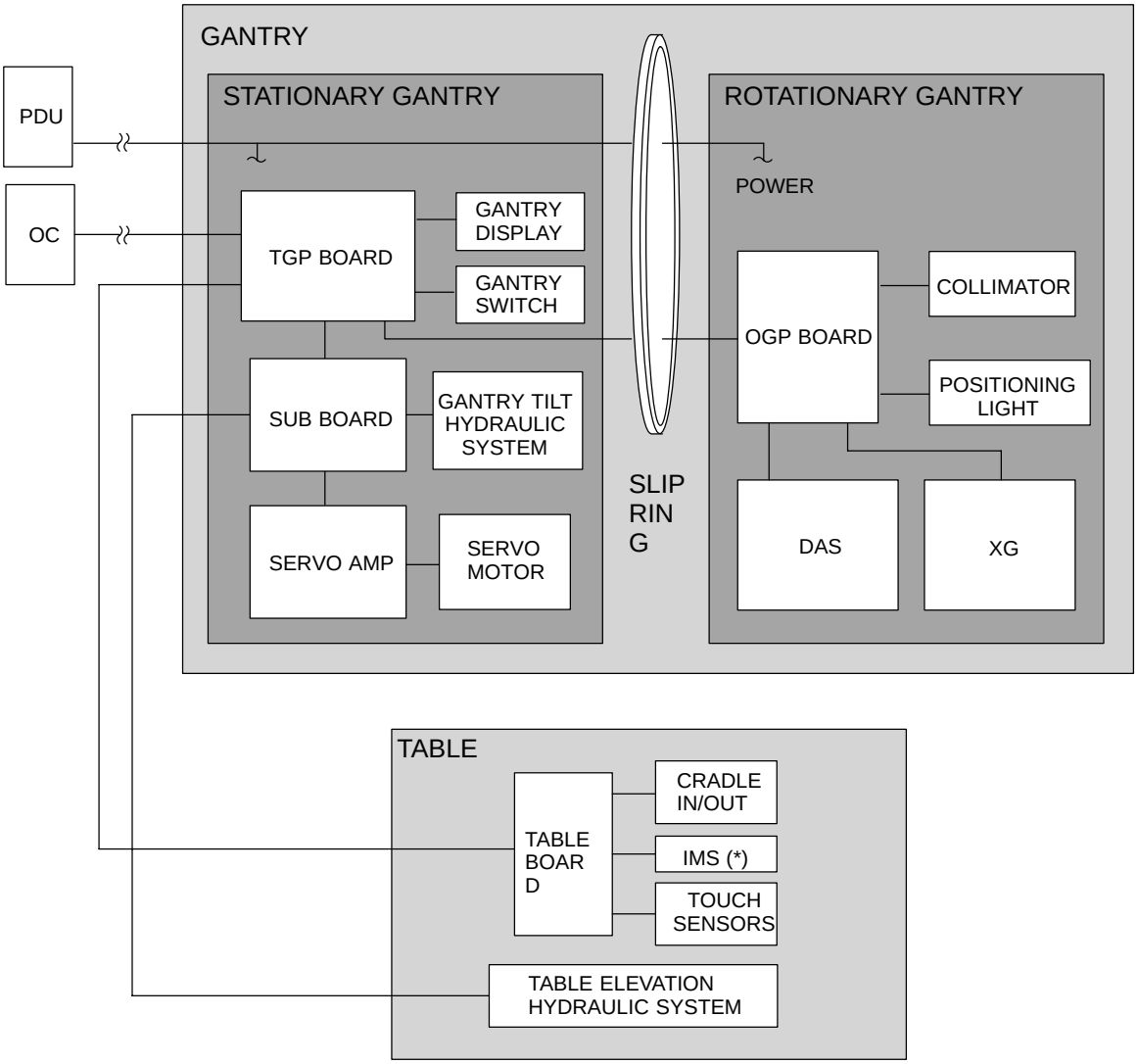
SECTION 2 – SUB–ASSEMBLY DESCRIPTION

2-1 OVERVIEW

The Table/Gantry consists of table and Gantry. The Gantry is divided into Stationary Gantry and Rotationary Gantry. The communication between stationary and rotationary Gantry is made by slip–ring, a rotation mechanism that permits electrical power and signals exchange.

The illustration 2–1 shows the Table/Gantry block diagram.

Illustration 2–1 Table/Gantry Block Diagram



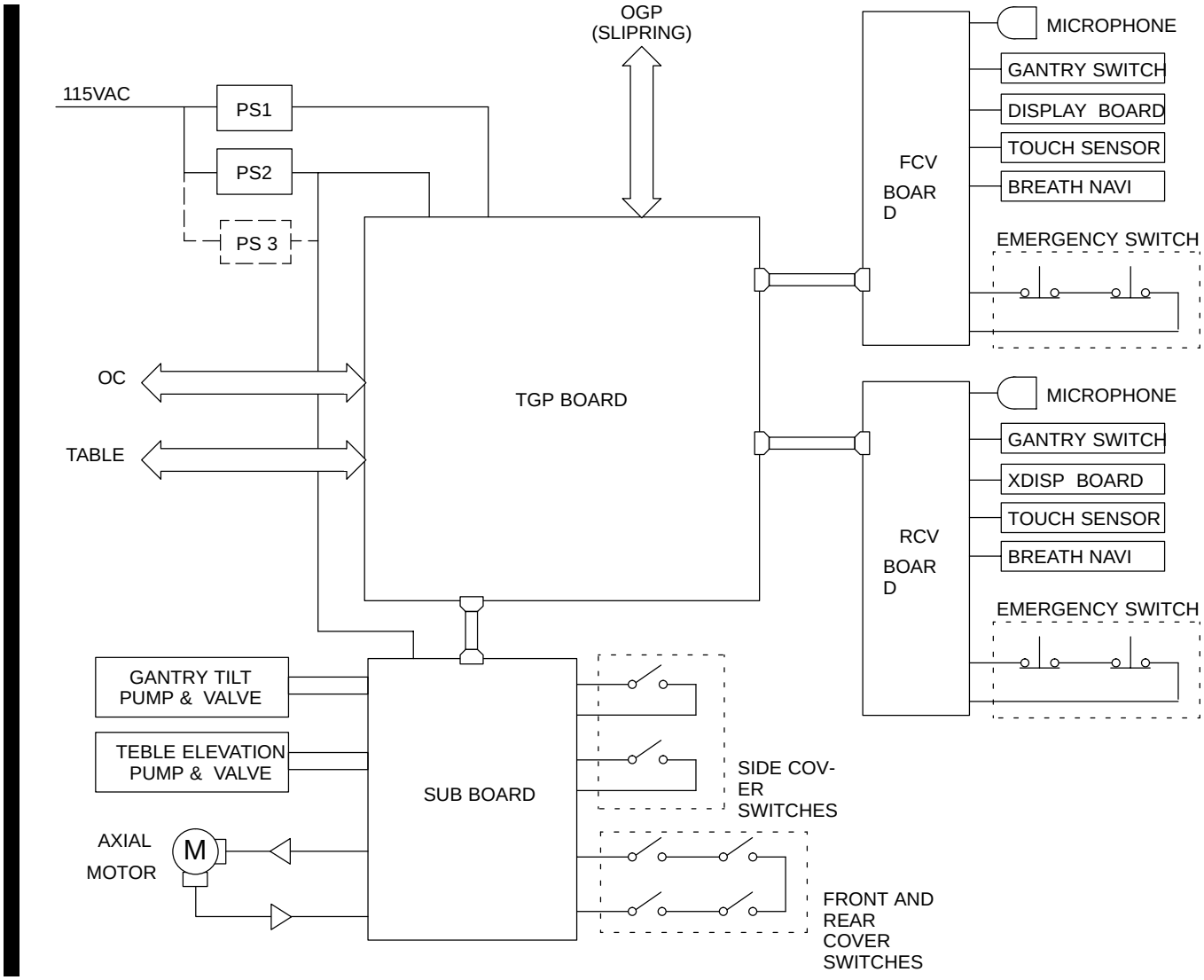
(*) Only for NP+

2-2 STATIONARY GANTRY

The stationary Gantry is mainly controlled by the TGP (Table Gantry Processor) board. The Illustration 2–2 shows the main components of the stationary Gantry.

The TGP board communicates with Operator Console and Table via cables and with the OGP board located in rotationary Gantry via cable and slipring.

Illustration 2–2 Stationary Gantry main components



The functions of the parts of the stationary Gantry are as follows:

PS1 and PS2

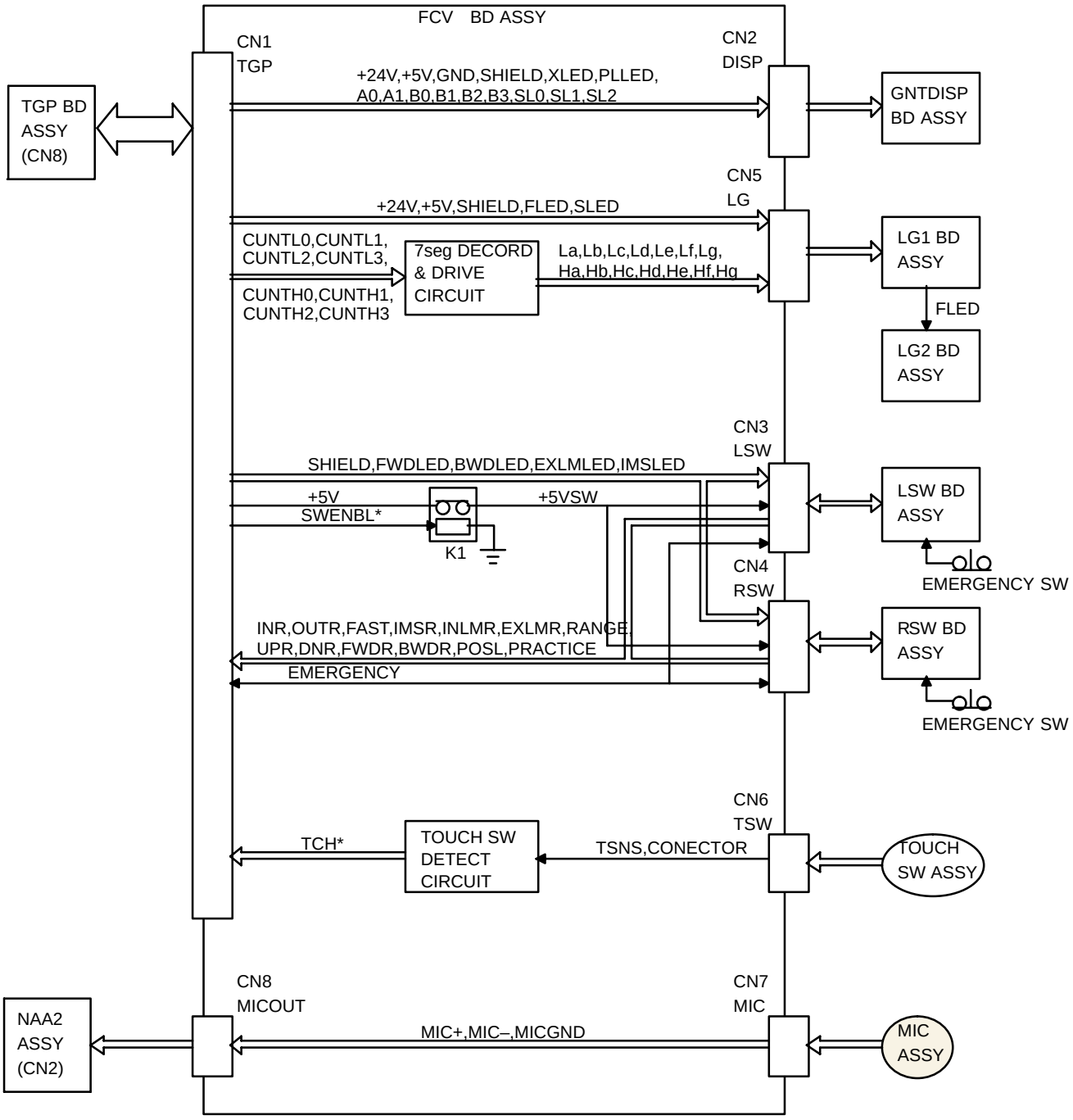
Supply power to TGP board and SUB board. PS1 supplies +5V, +12V and –12V. PS2 supplies +24V.

2-2 STATIONARY GANTRY (continued)

FCV (Front Cover) Board RCV (Rear Cover) Board

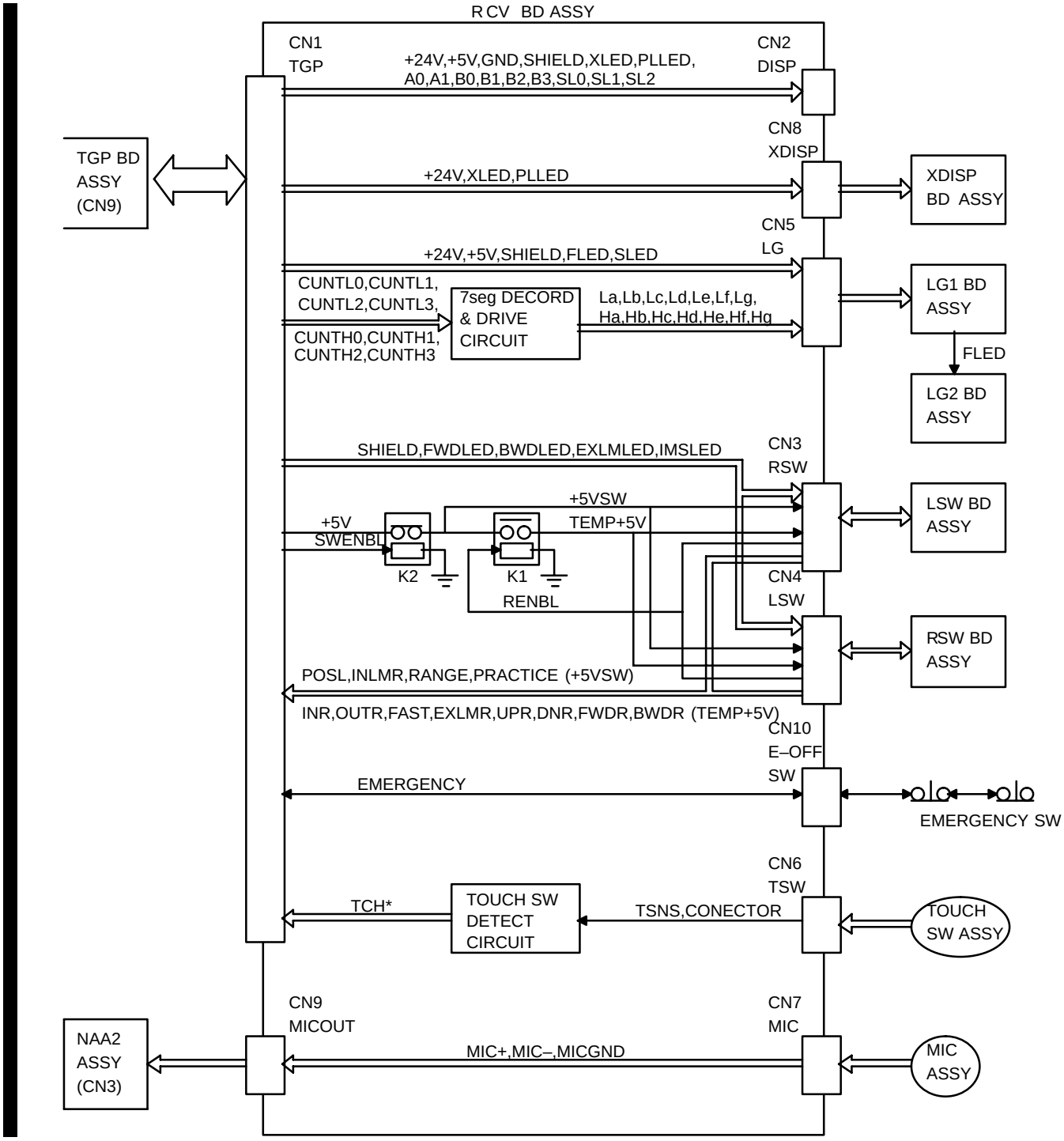
Contains connection circuitry to display board, touch sensors, breath navis and emergency switches. See Illustration 2–3 and 2–4.

Illustration 2–3 FCV Block Diagram



2-2 STATIONARY GANTRY (continued)

Illustration 2–4 RCV Block Diagram



2-2 STATIONARY GANTRY (continued)

Display Board and XDISP board

Display board is the display located at middle upper side of the Gantry front cover.

XDISP board is the smaller display located at middle upper side of the Gantry rear cover.

Gantry Switches

Located at left and right of both front and at rear Gantry cover. These switches are used to tilt manage Gantry tilt, table and cradle movement and positioning light.

Gantry Microphone

Located at upper portion of the entrance of the Gantry opening, at the front and the rear side.

Touch Sensor

Located at front and at rear upper side of the Gantry cover to protect patient during tilt. When touch sensor at the front cover hit something during forward tilt, the tilt stops. When touch sensor at the rear cover hit something during backward tilt, the tilt stops.

Breath Navi

Located at upper portion of the entrance of the Gantry opening, at the front and the rear side to notify patient to breath, hold breath and show remaining scan time.

Emergency Switch

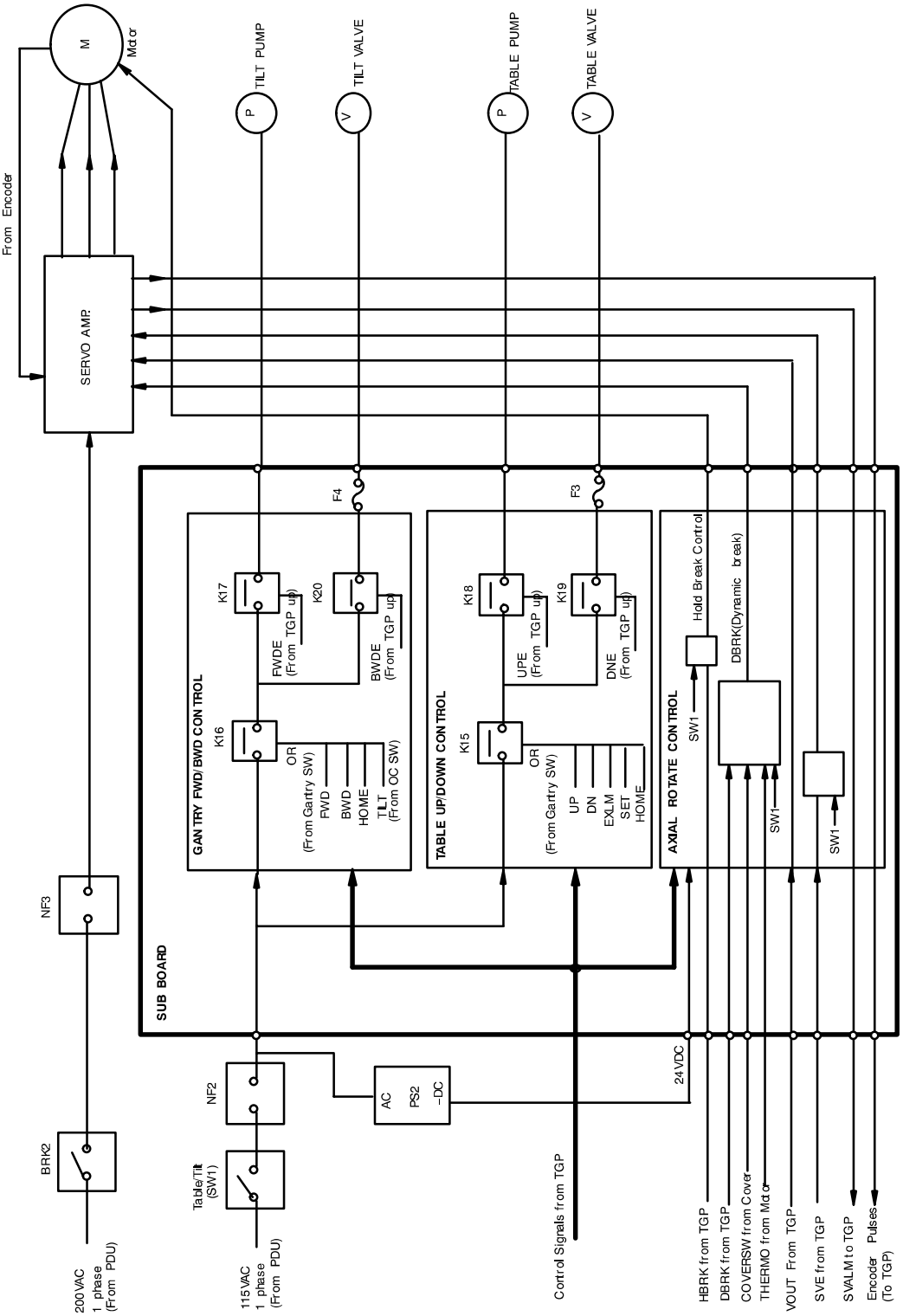
Located at left and right of both front and at rear Gantry cover.

SUB Board

The SUB board contains control circuitry for Gantry tilt, table elevation and servo amp for axial motor. Control these functions according to the command received from TGP board. Contains also connection to Gantry cover switches. See Illustration 2–5.

2-2 STATIONARY GANTRY (continued)

Illustration 2–5 SUB Board Block Diagram



2-2 STATIONARY GANTRY (continued)

TGP BOARD

There are three micro processors on the TGP Board. One controls the GANTRY Rotation, one controls the Table and the other controls the arbitration of commands from the gantry processor, table processor, scan processor (located on the OGP board) and the OC. See Illustration 2–6.

- Processor A for GANTRY CONTROL (GP)
- Processor B for TABLE CONTROL (TP)
- Processor C for MANAGEMENT (MP)

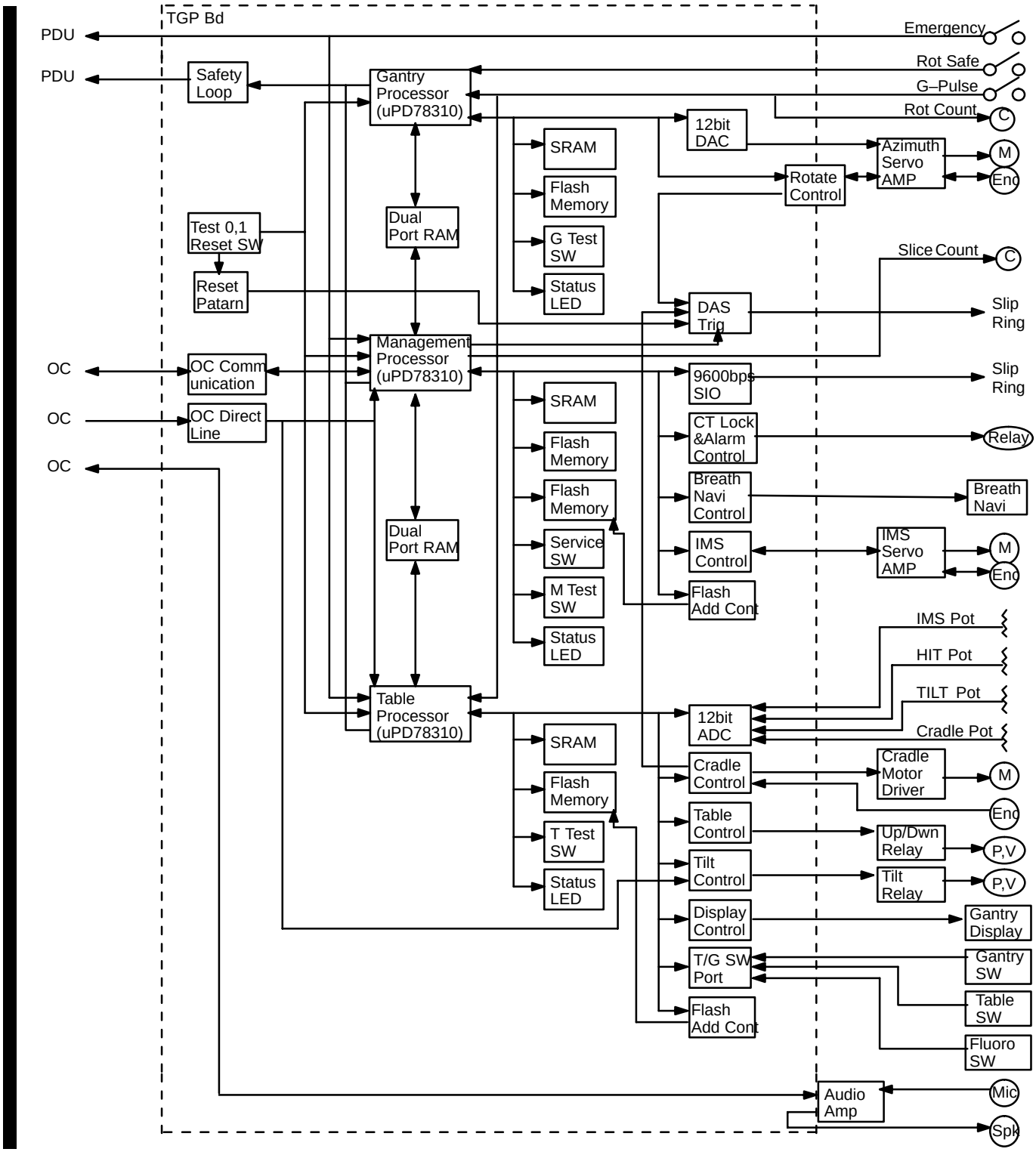
The Management processor communicates with the OC through serial links. The other processors (Gantry Processor and Table Processor) communicate with the Management Processor, and can receive commands from the OC via the Management Processor. The Gantry Processor and Table Processor also contain a serial communication port which is not used for communication between OC or other Processors, but rather is used for Data correction from the sensor switches.

The TGP Board issues commands *to* and receives status *from* the components it controls. The TGP oversees the following functions:

- AXIAL Drive control
- TILT Drive control
- CRADLE IN/OUT Drive control
- IMS IN/OUT Drive control
- TABLE Elevation Drive control
- GANTRY Display control
- Breath Navi Display control
- GANTRY panel switch/Foot switch control
- Error Detection

2-2 STATIONARY GANTRY (continued)

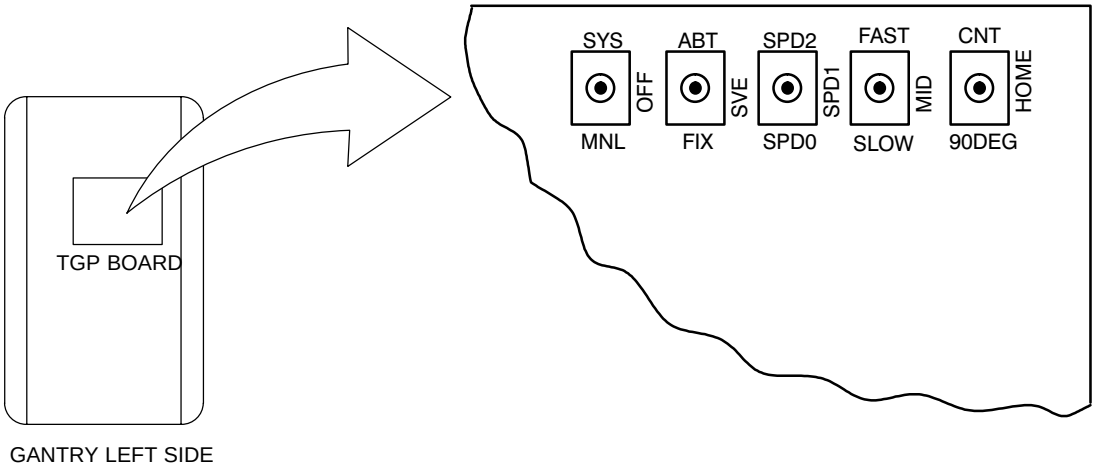
Illustration 2–6 TGP Block Diagram

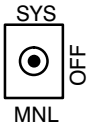


2-2-1 TGP board Service Switches

There are five service switches at right upper side of the TGP board which are used to control the Gantry Rotation manually.

Illustration 2–7 TGP Board Service Switches

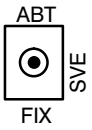




SYS : System Position. When the switch is in this position, the Gantry is controlled by the Operator Console.

OFF Disable the Gantry rotation. Servo Amplifier is disabled and Static brake activated.

MNL Manual Position. When the switch is in this position, the Gantry rotation is controlled manually, by the other switches described below.



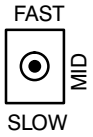
ABT : Arbitrary Mode. This switch is a spring loaded switch that enables Gantry rotation toward the direction selected by the rotation Direction switch (CNT/HOME/90DEG), by the fixed speed of XXX seconds per revolution.

SVE : Servo Enable. Servo Amplifier is enabled and voltage command is 0 volts, that means there is no rotation at this position.

FIX : Rotates Gantry according to the selection of the Speed Selection switches (SPD2/SPD1/SPD0 and FAST/MID/SLOW) and Direction switch (CNT/HOME/90DEG).

2-2-1 TGP board Service Switches (continued)

and



These two switches sets the rotation speed
See table below

SPD2/SPD1/SPD0	SPD2	SPD2	SPD2	SPD1	SPD1	SPD1	SPD0	SPD0	SPD0
FAST/MID/SLOW	FAST	MID	SLOW	FAST	MID	SLOW	FAST	MID	SLOW
SPEED (sec/rot)	0.7	0.8	1.0	1.5	2	3	5	10	15

CNT : Clockwise rotation
HOME : Home position (X–ray tube at zero degree position)
90DEG : 90 degree position (X–ray tube at 90 degree position)

2-2-2 TGP Processors

The TGP board contains three processors:

Management Processor (MP)

The Management Processor oversees the functions of the Table/Gantry. It communicates with OC and according to the message received from OC, sends corresponding commands to Gantry processor, Table processor and OGP board.

The main functions of the Management processor are:

- Communication with OC – serial link
- Communication with OGP – serial link through slipring
- IMS movement control
- X–ray ON LED (on Gantry panel) control
- Positioning Light ON LED (on Gantry panel) control
- Look guide control
- Practice Switch (for look guide) control
- Tilt position, table height and cradle position adjustment. There is a ROM connected to management processor that contains adjustment data. The management processor reads this data, compares with the current positions and make adjustment as needed.

2-2-2 TGP Processors (continued)

Gantry Processor (GP)

The Gantry processor control the following functions:

- Positioning light switch
- Gantry rotation

Table Processor (TP)

The table processor control the following functions:

- Cradle In/Out
- Gantry Tilt
- Table Up/Down
- Gantry Display
- Gantry Switch
- Interlock

2-3 ROTATIONARY GANTRY

The Illustration 2–8 shows the main components of the rotationary Gantry.

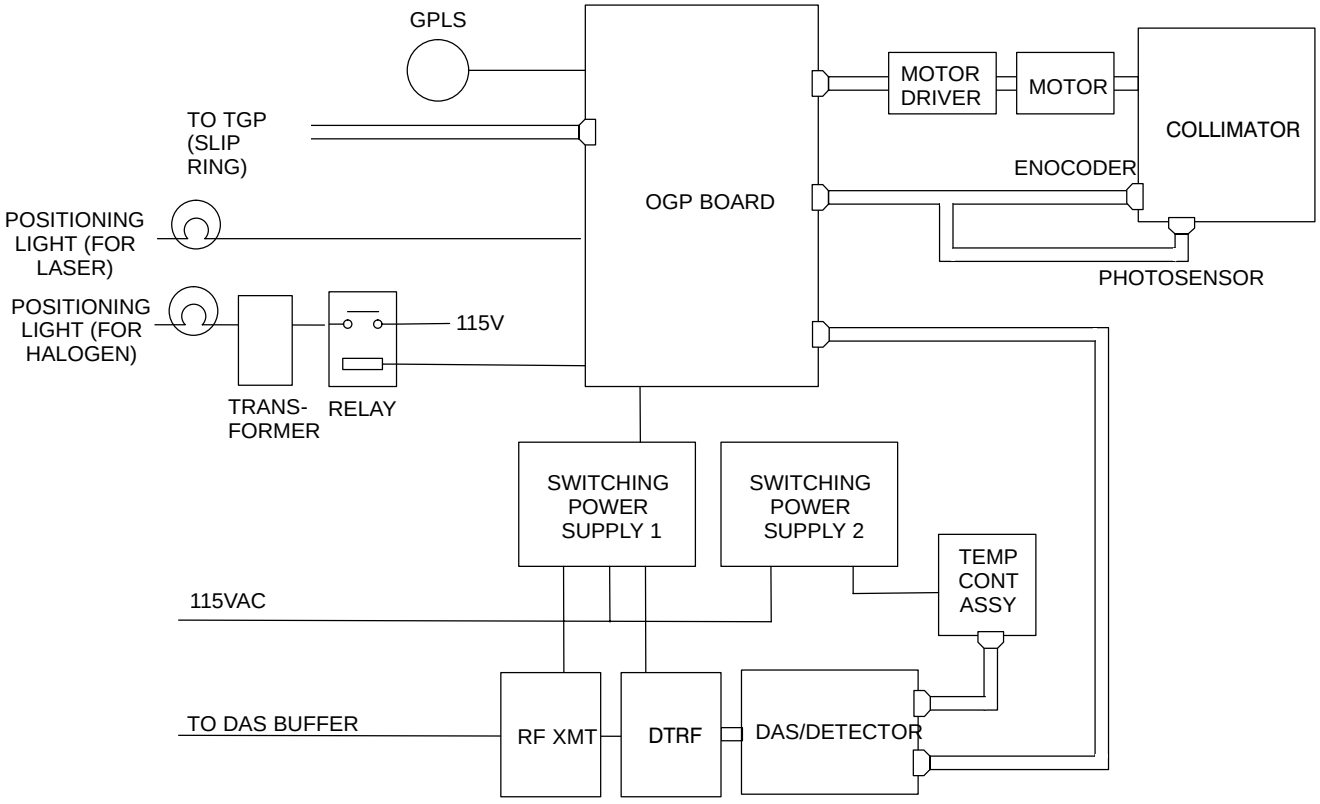
The functions of the parts of the stationary Gantry are as follows:

OGP Board

The OGP (On Gantry Processor) performs the following functions:

- X–ray exposure on/off control
- DAS data transfer timing
- Collimator control
- Positioning light control
- Scan control
- The automatic shut–off of the Tube Fan/Pump Power Supply after 30 minutes when the OC has been powered down.

Illustration 2–8 Rotationary Gantry main components



2-3 ROTATIONARY GANTRY (continued)

Switching Power Supply 1

Supply power to the OGP board, DTRF board, RF transmitter and positioning light.

Switching Power Supply 2

Supply power to the DAS and Temperature Control Box.

Collimator

Located at the exposure window of the X–ray tube, controls the aperture of the X–ray beam by moving the blades. The aperture can be 1,2,3,5,7 or10 mm.

Motor Driver

Generates five phase pulses to control the stepping motor of the collimator. Receives pulse command from OGP board and convert it to other type of pulses.

Encoder

Sends the feedback pulse to the OGP to show the moved amount of the blades.

Photo Sensor

Detects when the collimator blades are in 1mm aperture

DAS

Data Acquisition System. Processes the data received from detector and send it to operator console. The detailed explanations are in the DAS/Detector sections.

Temp Cont Assy

Device that controls the Detector temperature

DTRF

Receives parallel data from DAS and convert them to serial data. The detailed explanations are in the DAS/Detector sections.

RF XMT

Converts Serial signal from DTRF to RF signal.

GPLS

Notify TGP and OGP board when the Gantry is at zero degree tube position.

2-4 SLIP RING

The SLIP RING transfers the following signals;

- DAS Data
- DAS Trigger
- TGP and OGP Communication message
- Safety Loop

2-4-1 MECHANISM

This Gantry slip ring system utilizes:

- Nine 480VAC power brushes (3 power lines x3 brushes)
- Four 115VAC power brushed (2 power lines x2 brushes)
- Three ground brushes (1 ground line x3 brushes)
- Twenty–four signal brushes (6 signal lines x 4 brushes)
- RF transmitter / receiver modules

Every slip ring has a corresponding terminator located on the opposite side of the transmitter terminal. See illustration 2–9.

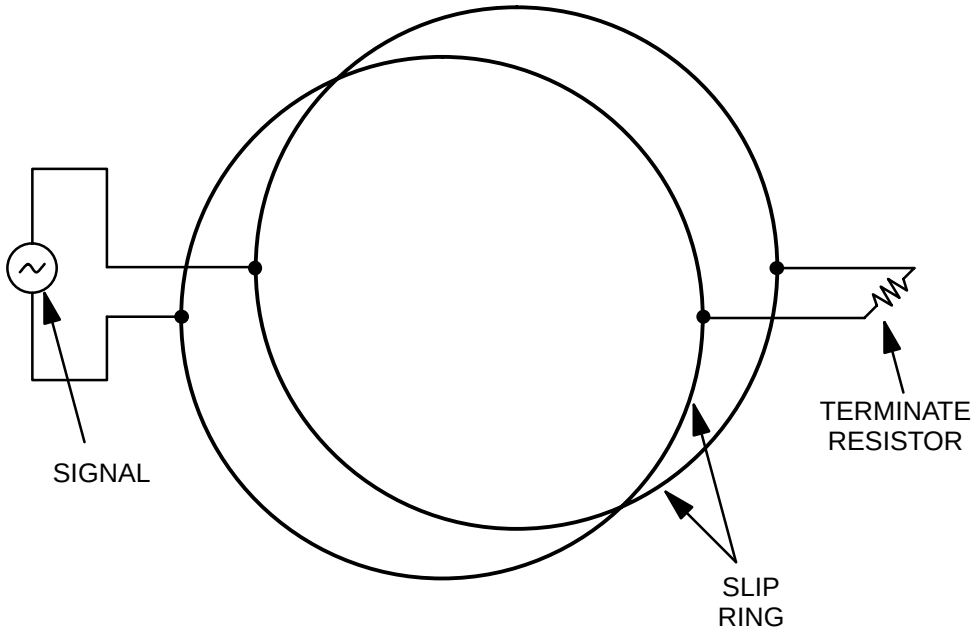


Illustration 2–9 Slip Ring Terminator

The characteristic Impedance should be less than or equal to approx. 50Ω.

2-5 TABLE

The Illustration 2–10 shows the main components of the table.

The description of the parts of the Table follows:

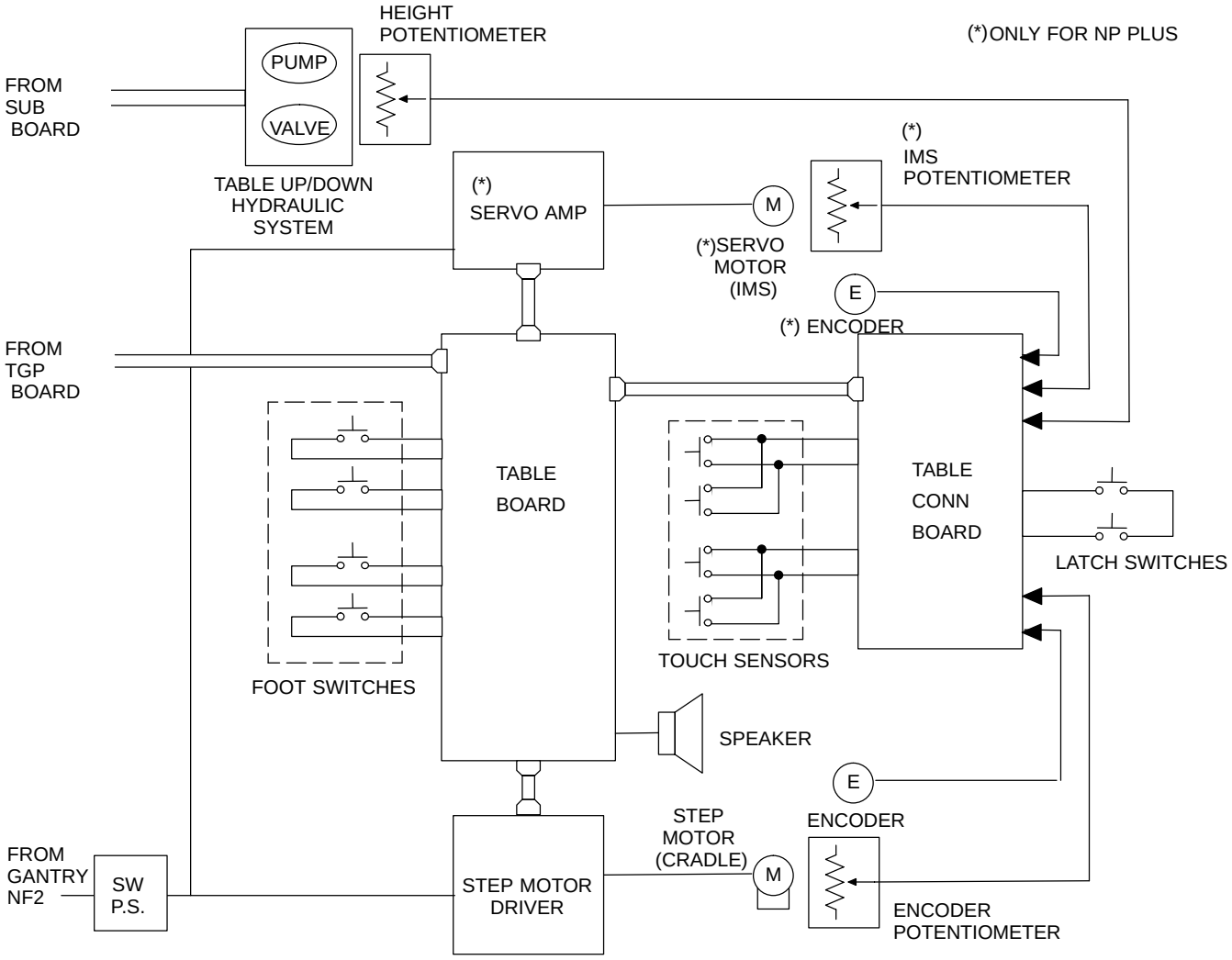
Table board

This is an interface board between TGP board and servo amp, stepping motor driver, and table CONN board.

TBL CONN board

This is an interface between Table board and potentiometers, touch sensors and latch switches.
This board has only connectors. For detail information, see schematic diagrams.

Illustration 2–10 Table



2-5 TABLE (continued)

Foot Switches

Pedals that controls Table Up/Down. When the Table is raised or lowered using foot switches, there is no cradle compensation.

Hydraulic System

Consists of pump, hose and cylinder. it is used for Table Up/Down.

Cradle

Portion of the Table that executes longitudinal movement. It is controlled by step motor and motor driver.

IMS (Intermediate Support)

Mechanism that aids the longitudinal movement in order to improve scannable range. It is controlled by Servo Amp and Motor. This is only for NP+.

Latch Switches

Positioned at both right and left sides of the Table, these switches release or latch the cradle. When both switches are pressed, the cradle is latched. When one of the switches is depressed, the cradle is released. They are for safety purpose.

Potentiometers

There are three potentiometers: IMS position potentiometer, height potentiometer and Encoder (tilt) potentiometer. They are used for feedback purpose.

Touch Sensors

Located at under surface of the Table. They are for safety purpose.

DAS/DETECTOR

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SECTION 1 – GENERAL DESCRIPTION

1-1 OVERVIEW

DAS/Detector subsystem consists of Solid State Detector and Data Acquisition System (DAS) that are located on the rotationary Gantry. X–ray data acquired by the detector is converted to light, then to electrical signal in the detector and then sent to DAS. The DAS digitizes, serializes and performs offset corrections on the signal and sends to the Operator Console for image reconstruction.

The X–ray exposure through the scanning object is detected by these modules, converted to light, then converted to electrical signal and sent to to the DAS. The DAS digitizes and sends this data by RF slipring and fiber optics to the Operator Console, where it is processed for image reconstruction.

Illustration 1–1 X–ray Exposure and Data Flow Block Diagram

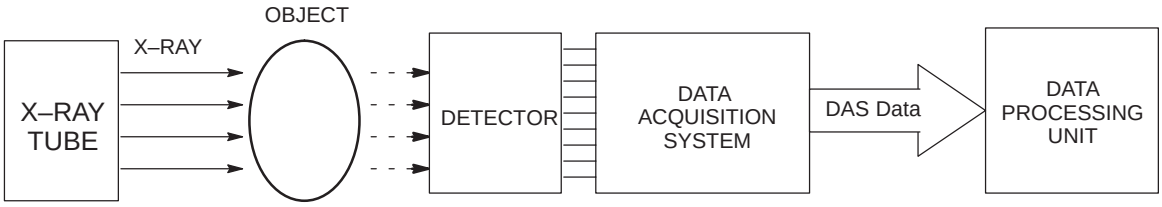
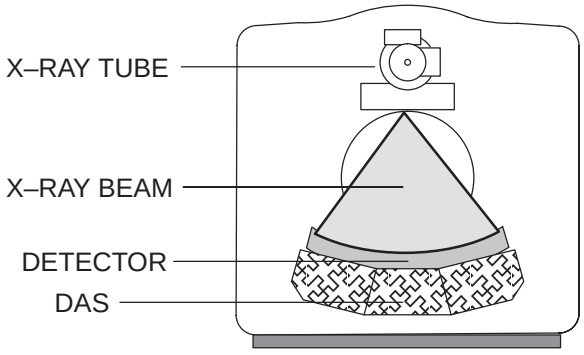


Illustration 1–2 X–ray Exposure and DAS/Detector



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SECTION 2 – DETECTOR

2-1 OVERVIEW

The detector consists of housing, collimator and detector modules. The detector module is made of scintillator (lumex crystal), photo–diode and connector. When the X–ray exposure is performed, the X–ray enters through the collimator and hits the scintillator. The scintillator is made of a material that emits light when hit by X–ray. The scintillator is in contact with photo–diode so that the light generated by X–ray is converted into electrical current. The generated current is sent to the DAS (Data Acquisition System) to be processed.

2-2 SPECIFICATIONS

Distance from Focus to ISO: 541 mm.

Distance from Focus to Detector surface: 949.075 mm.

Detector Channel Pitch: 1.15 mm.

Detector Channel angle: 0.06946 degree.

View Number:

- Offset: 64 views
- Active: 972 views

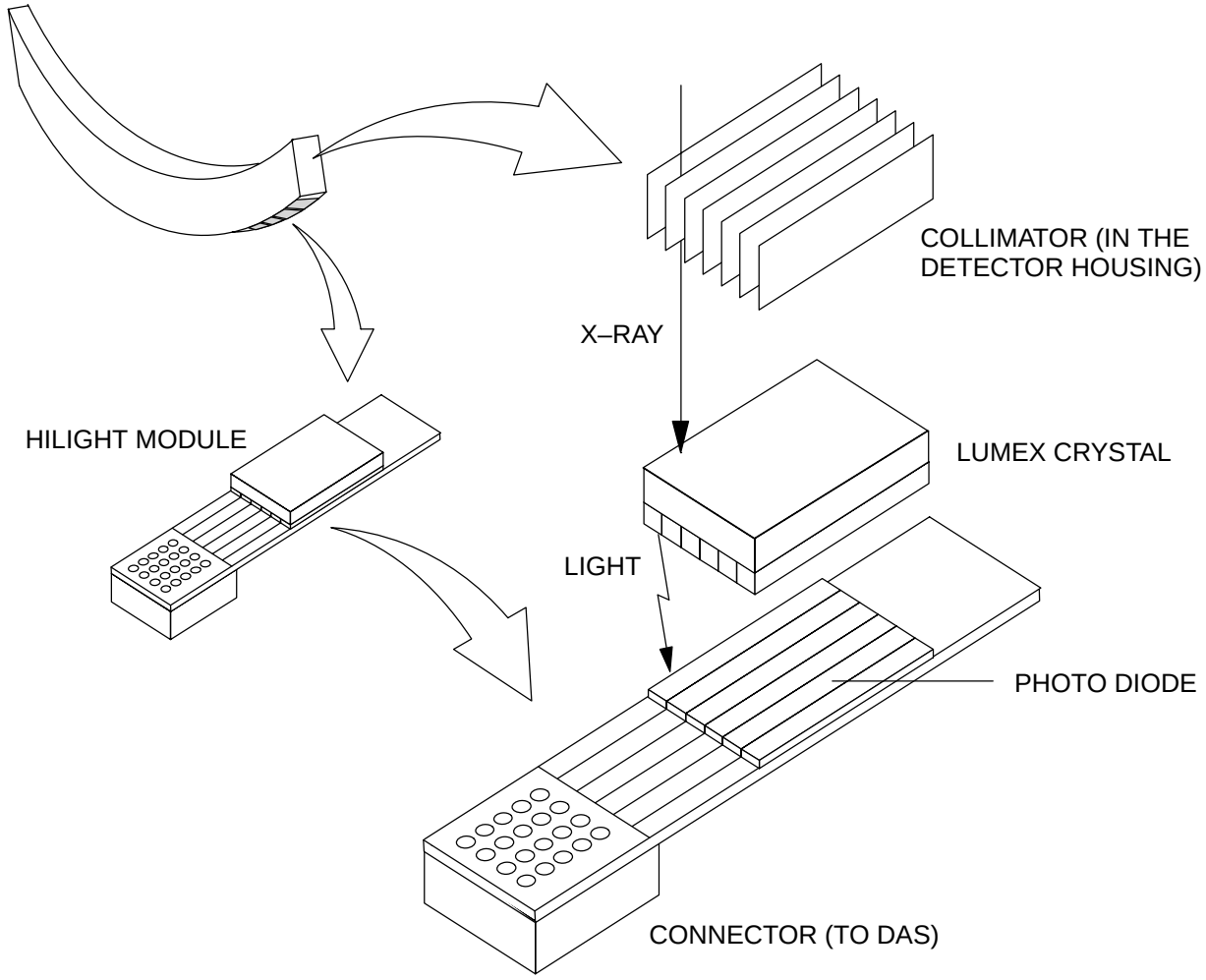
Channel Distribution:

	NP	NP+
Active Channel	717	793
Reference Channel	20	20
QCAL Channel	3	3
GND Channel	12	0

2-3 HILIGHT DETECTOR MODULE

The module consists of Scintillator cells, Collimator, Photo Diode, Reflex Films and Connector (illustration 2–1. The X–ray enters through the collimator (tungsten plates) and is absorbed by the Scintillator. The Scintillator is made of Lumex Crystal, the material that emits light when absorbs X–ray radiation. The Scintillator is optically coupled with Photo Diode which converts light to electrical current. The Photo Diode is electrically connected to DAS through the connector.

Illustration 2–1 DETECTOR MODULE



2-4 CHANNEL DISTRIBUTION

The illustration 2–2 and 2–3 shows the channel distribution.

Illustration 2–2 NP+ DETECTOR CHANNEL DISTRIBUTION

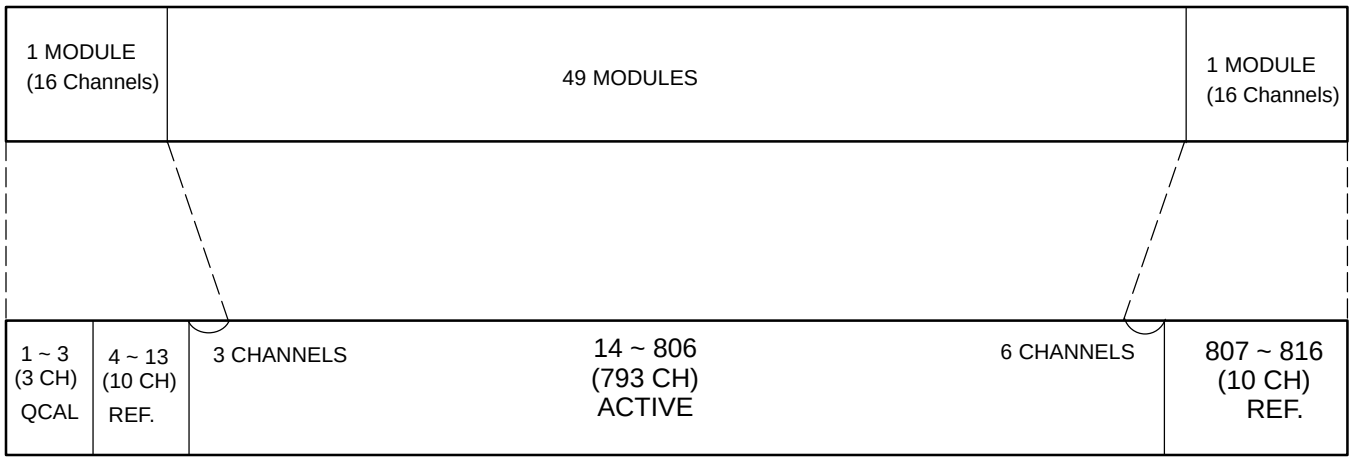
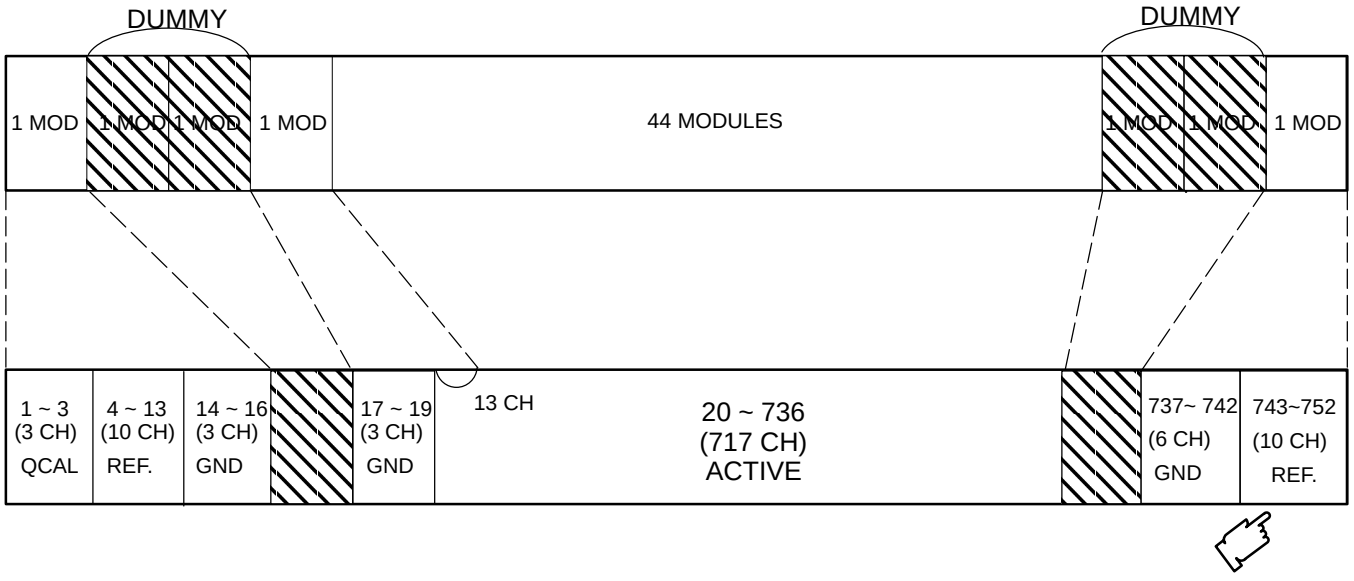


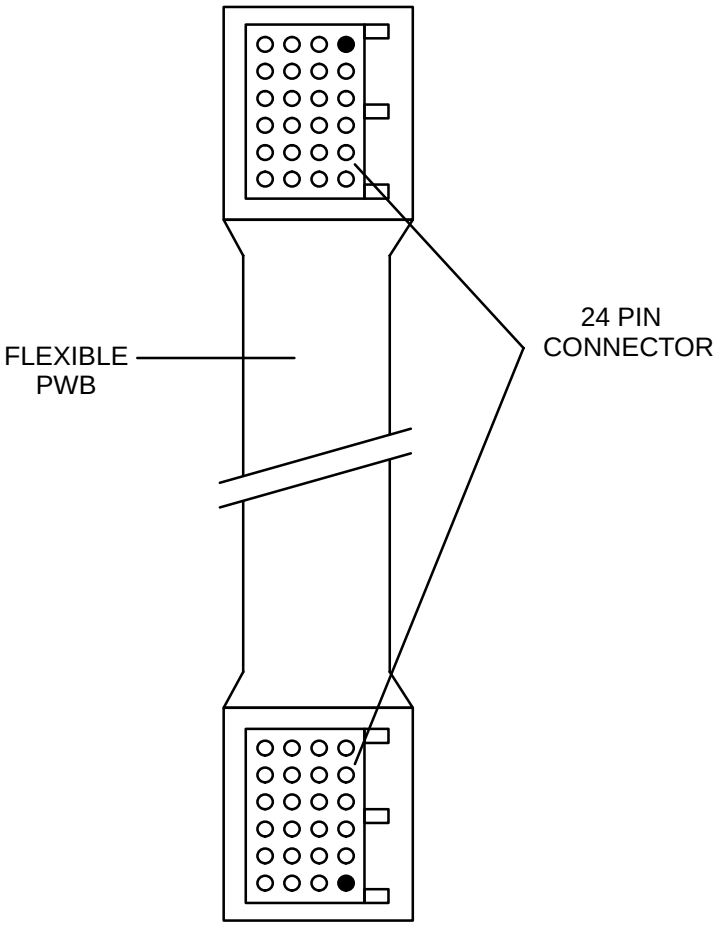
Illustration 2–3 NP DETECTOR CHANNEL DISTRIBUTION

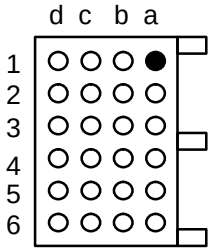


2-5 DAS/DETECTOR CONNECTOR

The detector module consists of 16 channels. The illustration 2–4 shows the flexible PWB that connects detector modules to the DAS (CAM boards) and its pin configuration.

Illustration 2–4 DAS/DETECTOR CONNECTOR



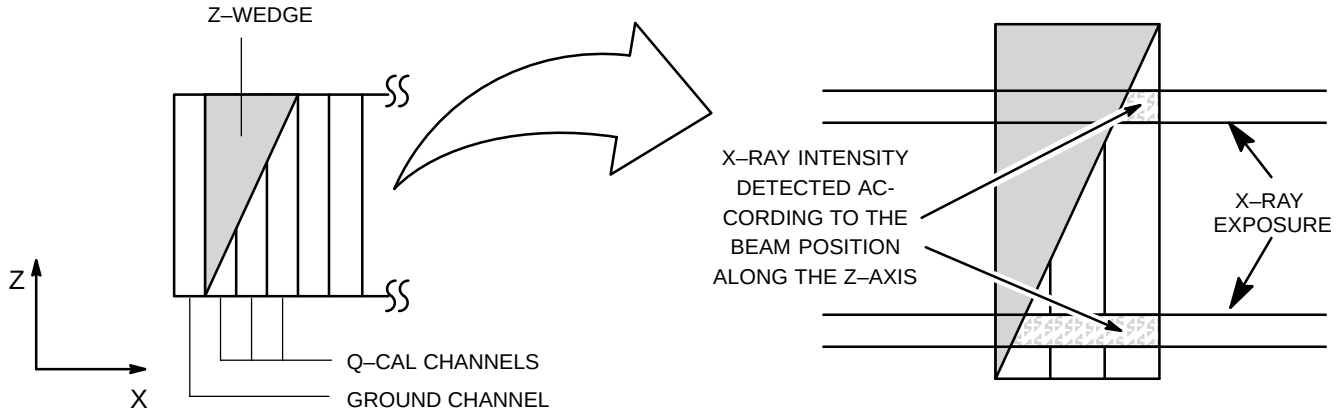


	a	b	c	d
1	CH 7	CH 8	CH 9	CH10
2	CH 5	CH 6	CH11	CH12
3	CH 3	CH 4	CH13	CH14
4	CH 1	CH 2	CH15	CH16
5	FG	FG	SG	SG
6	FG	FG	SG	SG

2-6 QCAL CHANNELS

The X–ray exposure can move along the Z–axis. It can be due to mechanical adjustment or to tube temperature (the angle of the X–ray output can vary according to the temperature). There is three channels in the left most positioned detector module that is used for Z–axis data correction. In this module there is a wedge shaped lead block, called Z–WEDGE (illustration 2–5). The outputs of the three channels are tied together so that only one data is taken for three channels. The corresponding intensity according to the position of the X–ray exposure along the Z–axis is detected (as can be seen at right side of the illustration 2–5), so that the system recognizes the current X–ray position (along the Z–axis). There is a remaining data for Z–axis data correction in the system. Therefore, the correction is made according to the data acquired by the Q–CAL channels.

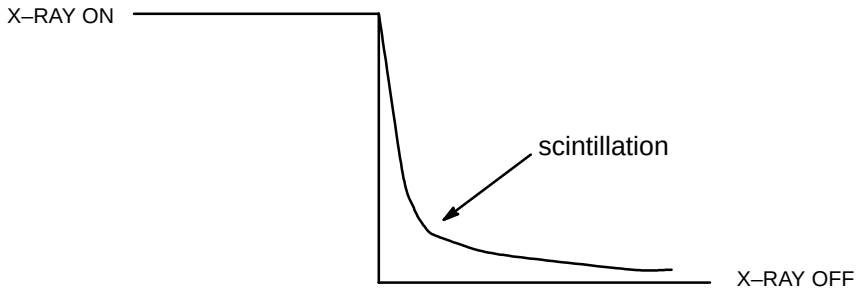
Illustration 2–5 Q–CAL CHANNELS



2-7 AFTER GROW

The Lumex crystal scintillator has a property represented in the illustration 2–6. The scintillator continues emitting light even after the X–ray radiation is stopped. This phenomenon is called AFTER GROW. This remaining scintillation provides incorrect data, but the system performs the error correction to eliminate this portion.

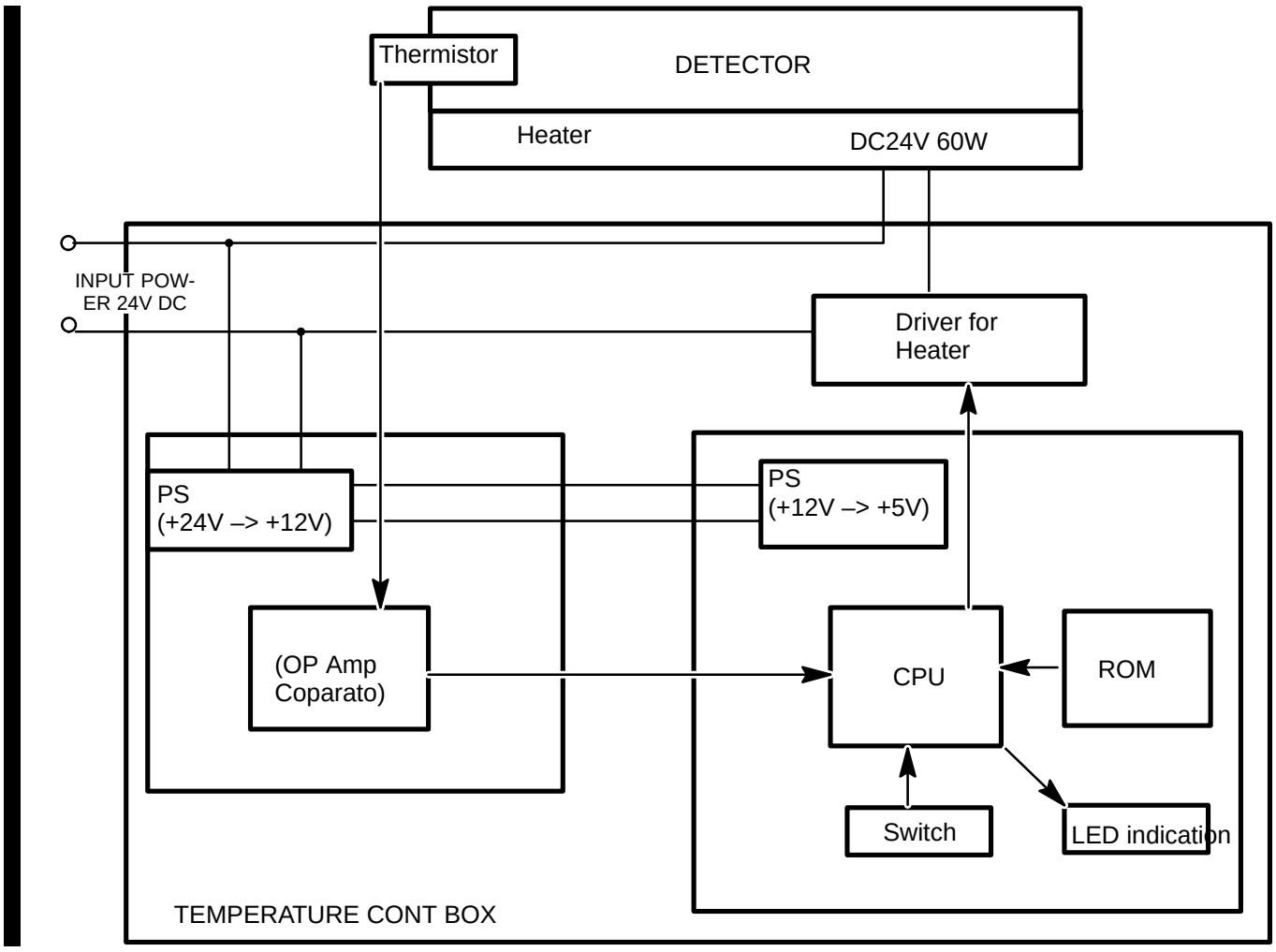
Illustration 2–6 AFTER GROW



2-8 HEATER AND TEMPERATURE CONTROL

The detector comprises a heater unit. The heater keeps the detector temperature constant, what is needed for detector accuracy. The heater is controlled by the Temperature Control Box which supplies power to the heater. The detector also comprises a thermistor that feeds back the temperature information to the Temperature Control box. Approximately three hours is needed after turning ON the power to the Temperature Control box to stabilize the detector temperature. The temperature is controlled to 35 ± 0.5 °C. The illustration 2–7 shows its block diagram.

Illustration 2–7 TEMPERATURE CONTROL BLOCK DIAGRAM



SECTION 3 – DATA ACQUISITION SYSTEM (DAS)

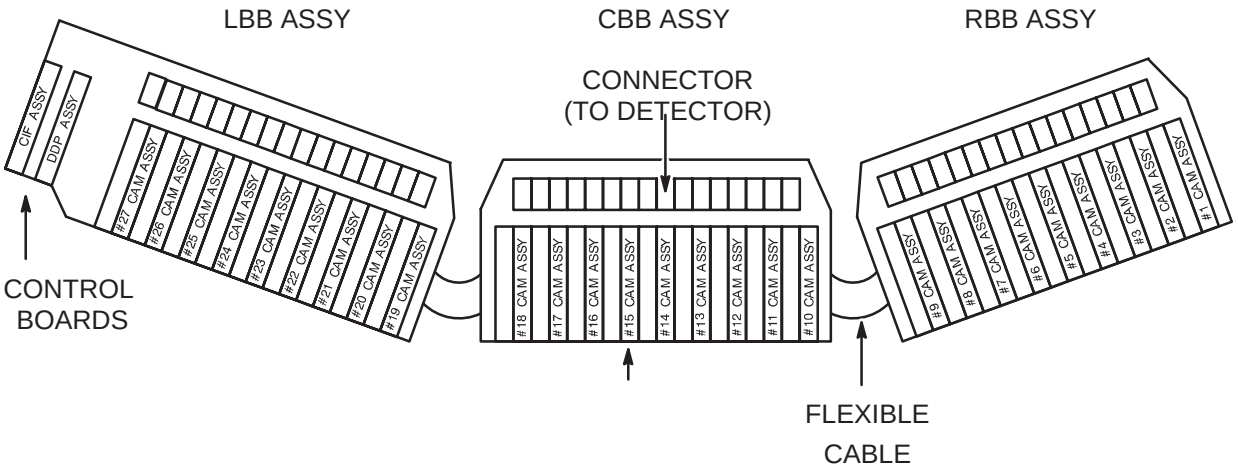
3-1 OVERVIEW

The DAS consists of the following boxes: RBB (Right Back Board), CBB (Center Back Board), and LBB (Left Back Board). Each box contains the set of boards as follows:

- RBB – 9 CAM boards
- CBB – 9 CAM boards
- LBB – 9 CAM boards, 1 DDP board, 1 CIF board

The Illustration 3–1 shows the DAS boxes.

Illustration 3–1 DAS (RBB, CBB, LBB)



The DAS channels number is as follows:

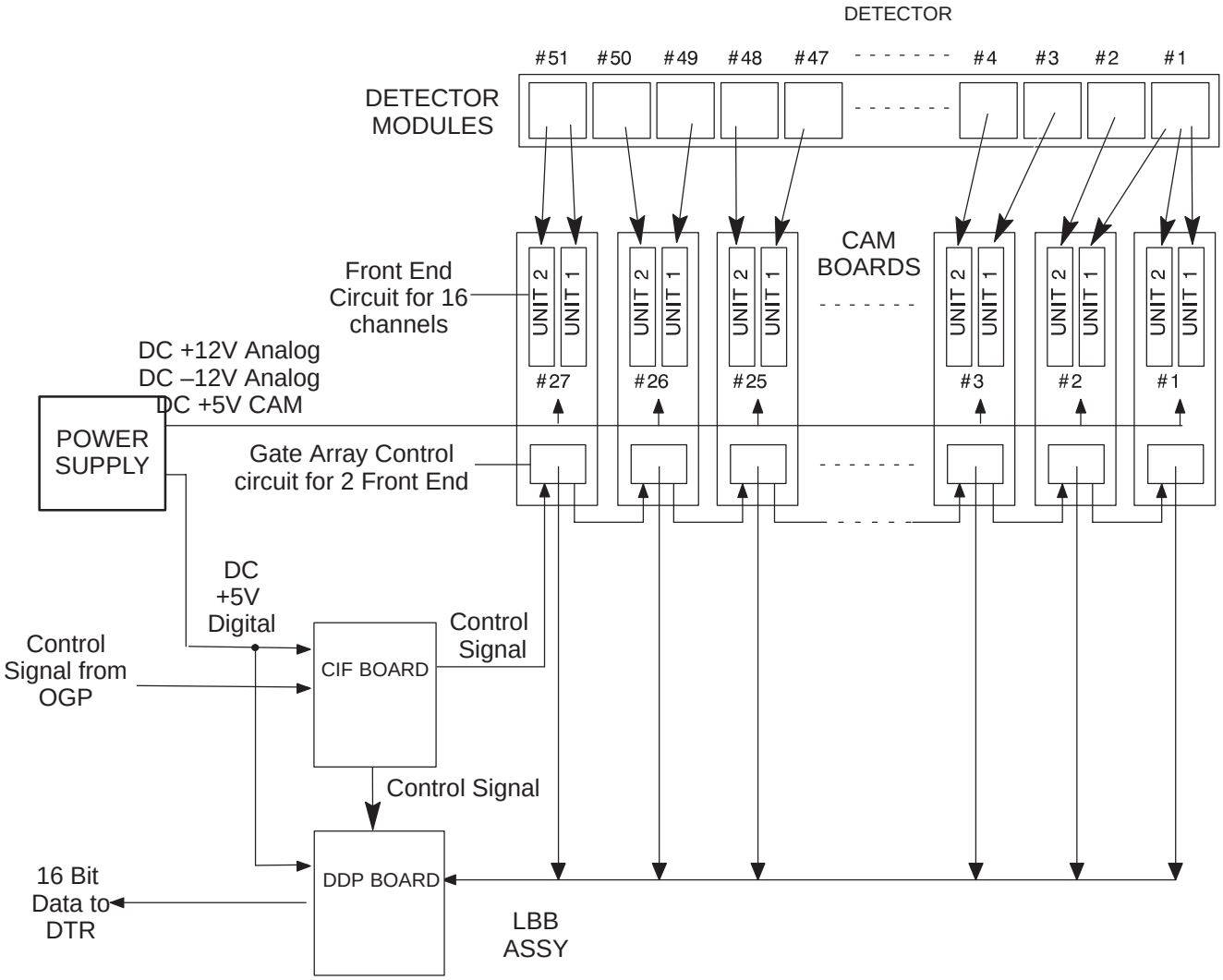
	NP	NP+
Active Channel	717	793
Reference Channel	10 + 10	10 + 10
QCAL Channel	3	3
Ground Channel	3 + 3 + 6	0

3-1 OVERVIEW (continued)

The illustration 3–2 shows DAS block diagram.

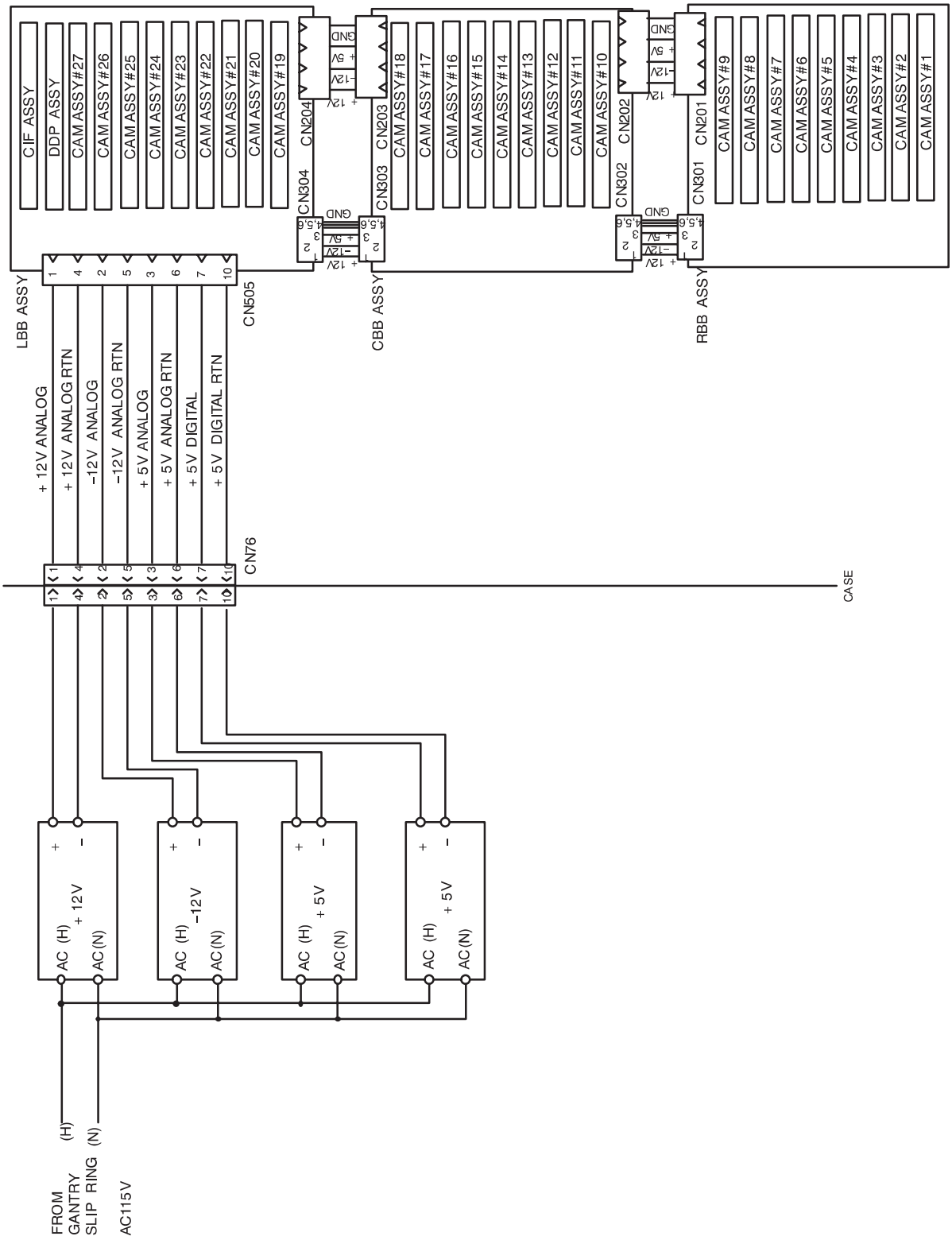
The data coming from the detector is taken by the CAM boards, sequentially channel by channel, digitized, converted to parallel, go through offset correction, then sent to the Operator Console. The CIF board is an interface with OGP (On Gantry Processor) receiving control and timing signals, and generates the timing signals for data gathering. The DDP board performs offset correction and generates the test pattern.

Illustration 3–2 DAS/Detector Structure



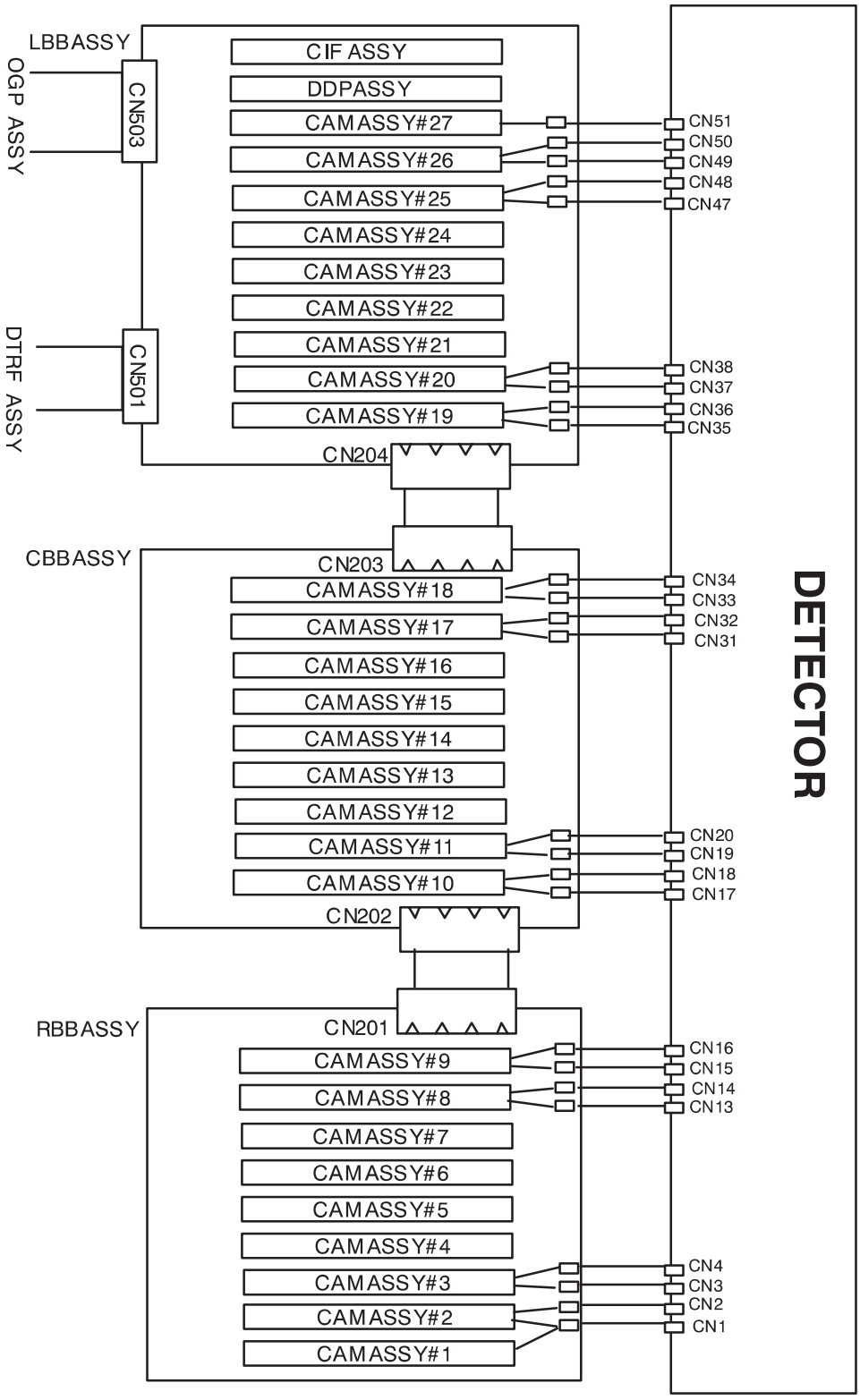
3-1 OVERVIEW (continued)

Illustration 3–3 DAS Power Connection



3-1 OVERVIEW (continued)

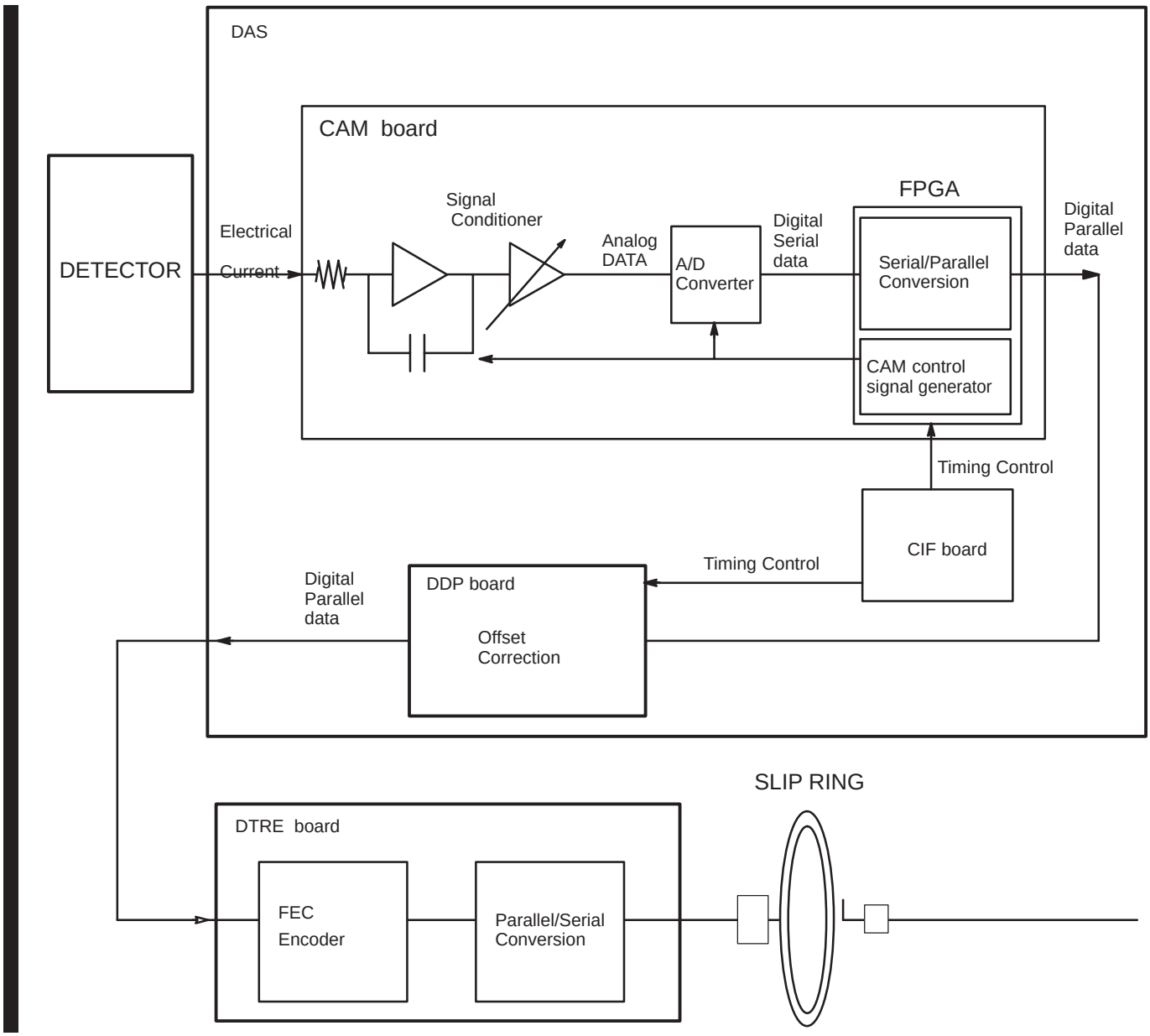
Illustration 3–4 DAS Signal Connection



3-2 DATA FLOW

The illustration 3–5 shows the data flow. The Detector generates an electrical current proportional to X–ray intensity. The electrical current is converted to voltage signal in the CAM board. The voltage signal is amplified to an appropriate level, converted to digital data (serial), then converted to parallel data, also in the CAM board. The offset correction of the data is performed in the DDP board. The data is then sent to to DTRE board where it is converted back to serial, conditioned and then sent to Operator Console through the RF Slipring.

Illustration 3–5 DAS block diagram



3-3 CIF BOARD

The CIF board performs the following functions:

- OGP Interface: exchange signals with OGP to control and synchronize the data acquisition.
- Control signals: generates control and timing signals to the other boards in the DAS for data acquisition.

OGP Interface

The DAS subsystem receives scan control signals from OGP board, by which the CIF board generates control signals for data acquisition. The exchanged signals with OGP are shown in illustration 3–6 and the functions of the signals is as follows:

DTRIG : DAS trigger – This is the timing signal initiates for data acquisition.

AXAL 16pulses/view
SCOUT 1pulse/view

DENBL : DAS enable – indicates that the data is valid.

H : data valid
L : data invalid

SDCOM : Serial Communication data from OGP to CIF (including signals, ZERO DETECT and OVER RANGE).

DSCOM : Serial Communication data from CIF to OGP (including signals, ZERO DETECT and OVER RANGE).

GPLS2 : Home Position

H : home position
L : not in home position

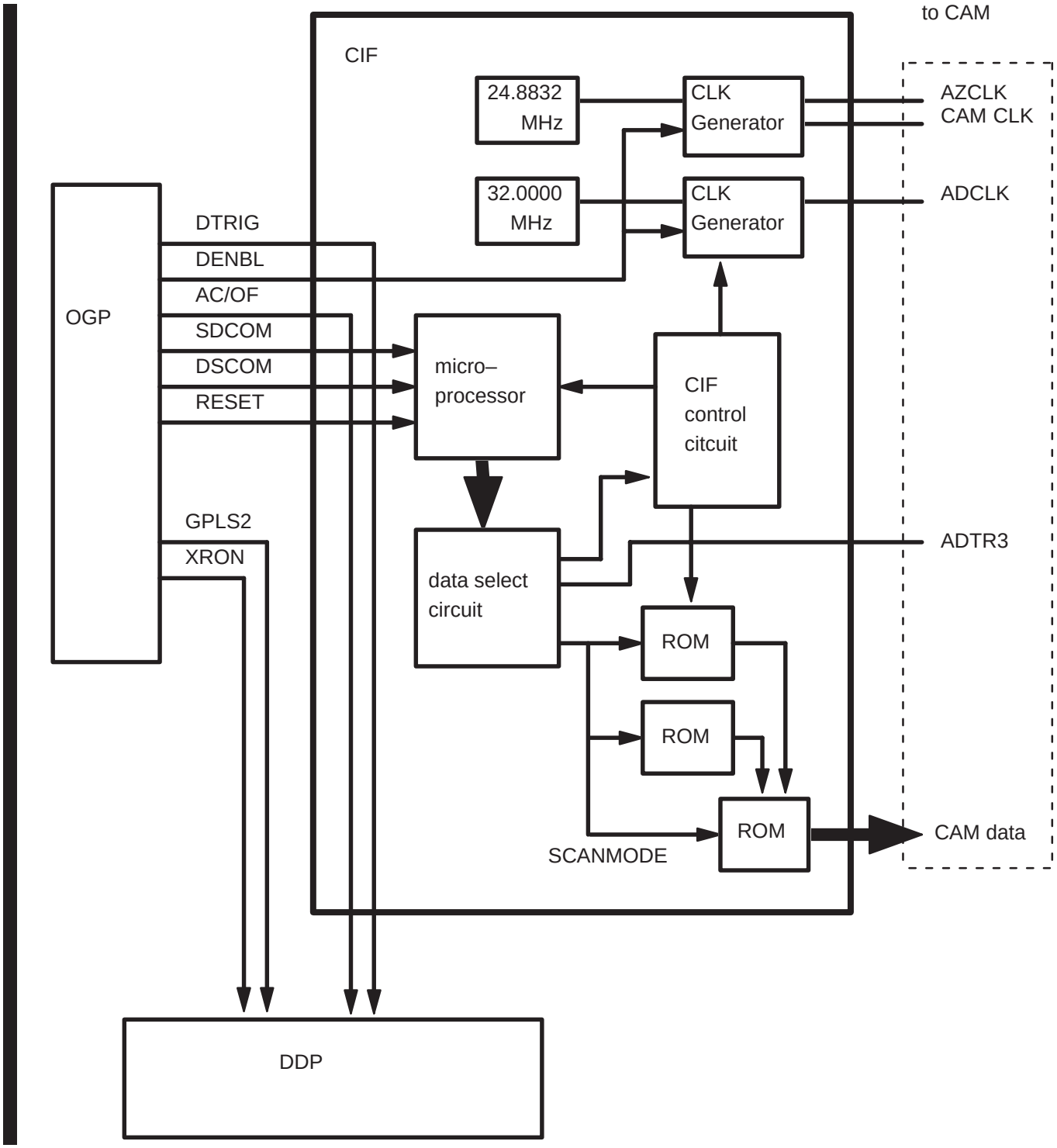
AC/OF : Signal to indicate if the scan is active or offset.

XRON : Signal to indicate that X–ray exposure is On.

RESET : Reset signal for microprocessor in the DAS.

3-3 CIF BOARD (Continued)

Illustration 3–6 CIF board block diagram



3-4 CAM BOARD

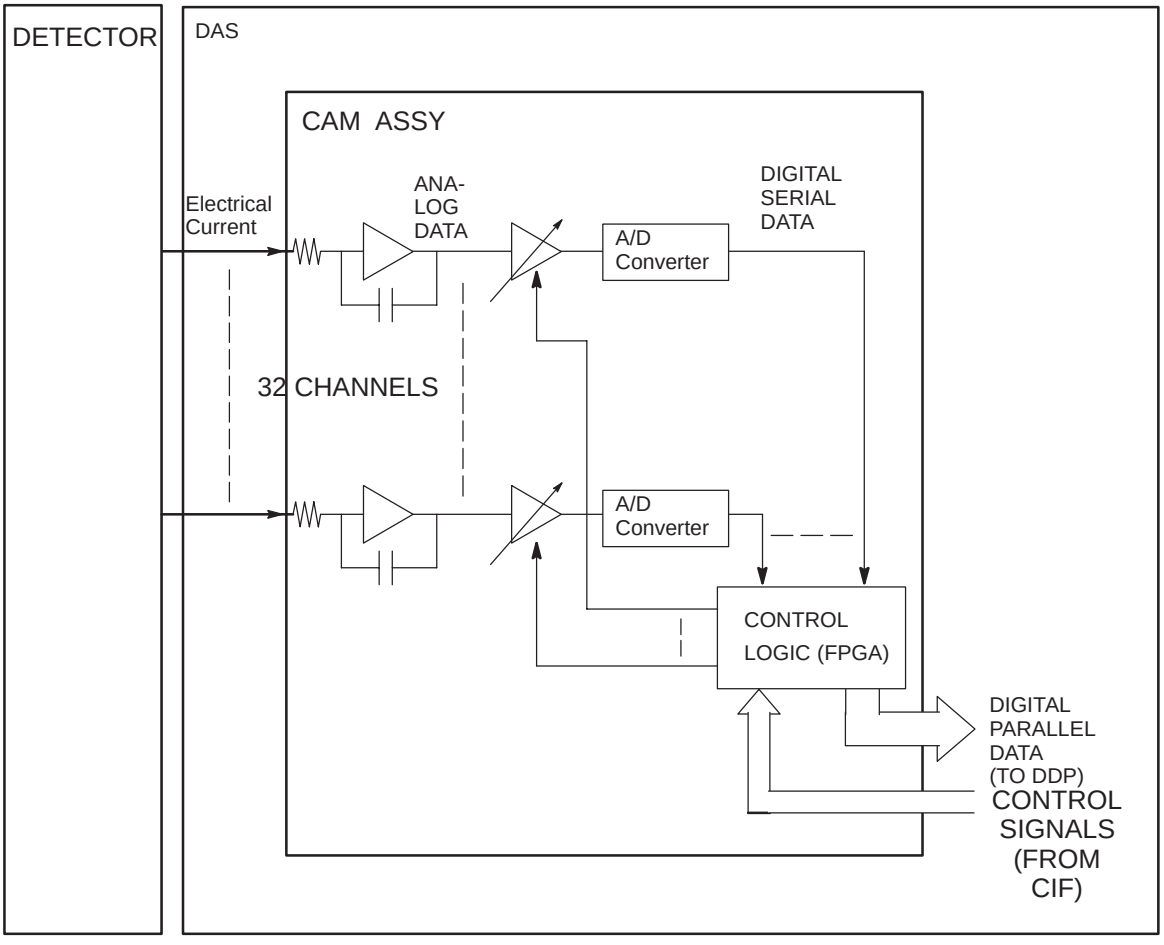
The CAM board performs the following functions:

- Conversion of electrical current signals from the detector to voltage signals.
- Signal level conditioning
- Analog to Digital conversion
- Serial to parallel (digital data) conversion.
- Generation of the timing signals for data gathering

See Illustration 3–7. The signal from the detector with the level proportional to the X–ray intensity is fed to the CAM board. The signal go through the electrical current to voltage signal conversion and conditioning circuits then is fed to the Analog/Digital(A/D) converter. The A/D converts analog signal to 16 bits digital serial data. The serial data is then sent to the control logic and converted to parallel data.

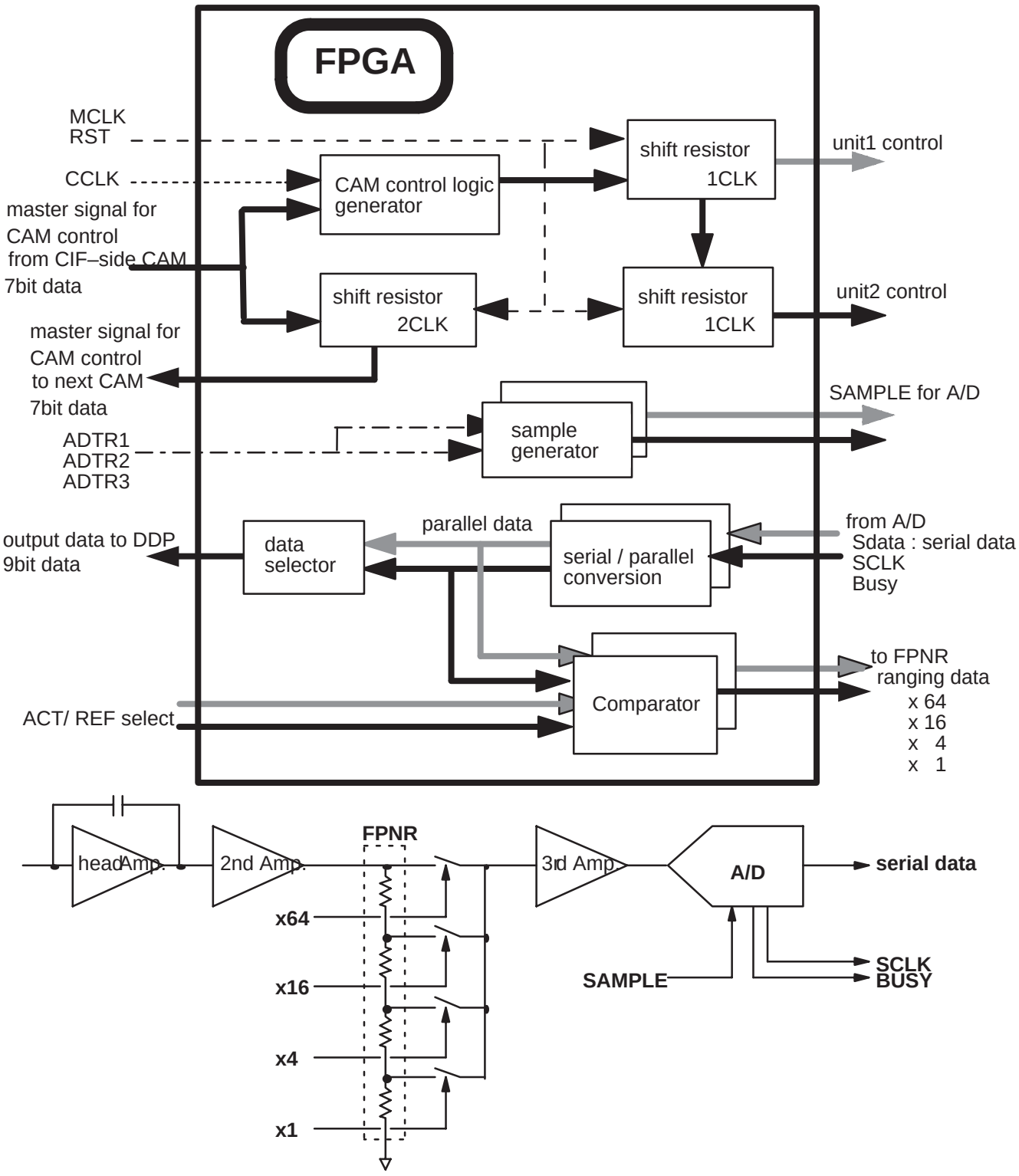
The control logic also generates the timing for data gathering, so that 1 channel data is taken at a time. This part of circuit works synchronized with other CAM boards so that the data in entire DAS is taken a determined sequence.

Illustration 3–7 CAM board block diagram



3-4 CAM BOARD (Continued)

Illustration 3–8 Control Logic (FPGA) block diagram



3-5 DDP BOARD

The DDP board performs two functions: Offset data correction and test patter generation.

Offset Correction

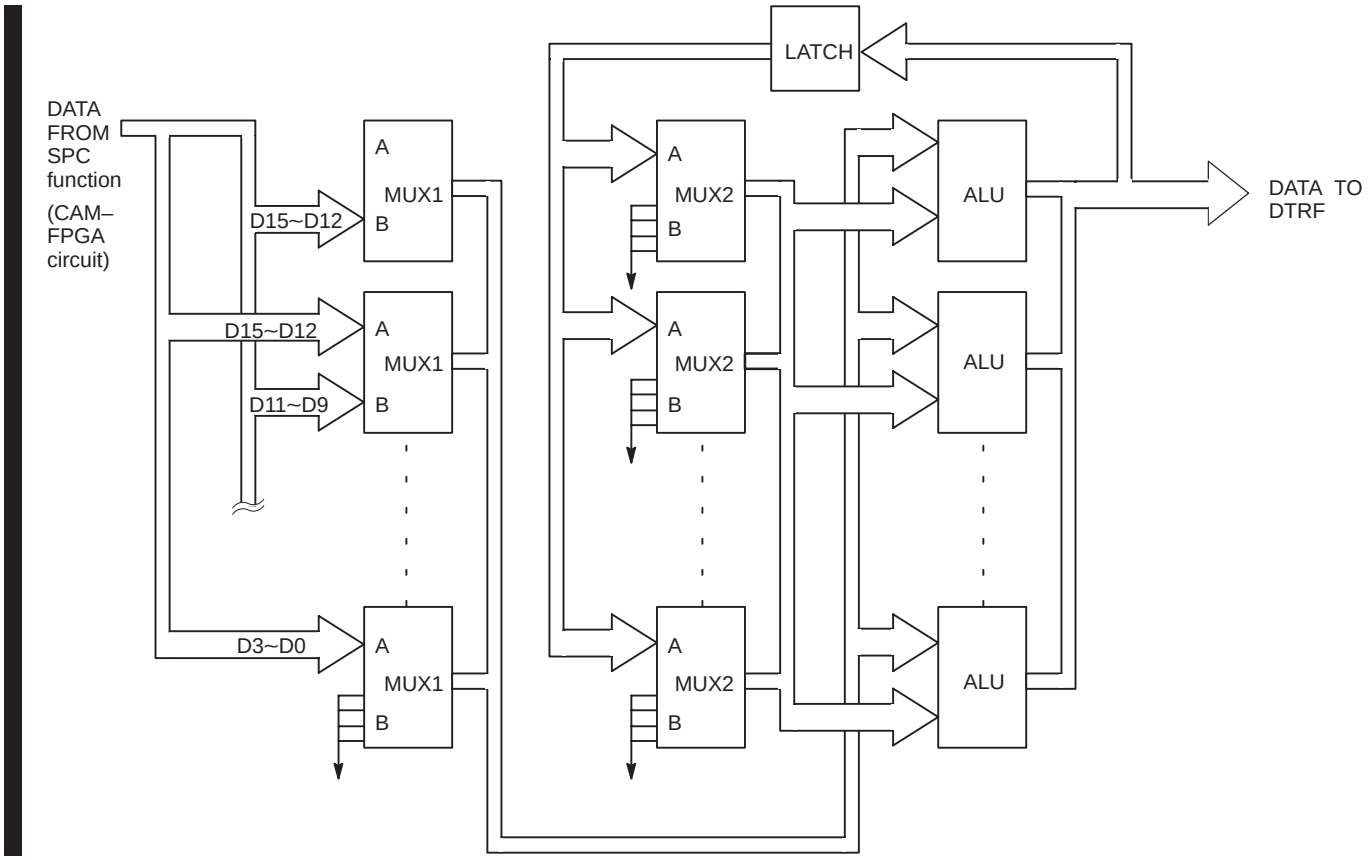
The digital data coming from CAM board contains offset portion due to electronic circuitry and offset scan. The illustration 3–9 shows a simplified block diagram of the offset cancel circuit in the DDP board.

The multiplex blocks MUX1 select inputs ports A or B according to the data type. Port A or B is selected if the data is or active respectively. These mltiplexer shift data by 4 bits. Both offset and active data are 16 bits long.

When first offset data comes, the multiplexers MUX2 select port B so that ”0” is added (by ALU – Arithmetic Logic Unit) to the offset data. The result of this operation is then latched to the block ”LATCH” in illustration 3–9. From the next offset data on, the multiplexers MUX2 select input A so that the latched former result is added to new offset data. this operation is repeated 16 times, what leads to 20 bits data.Only 16 most significant bits are taken, which results in the average of the sum. This data is taken as a subtraction factor for offset correction.

During normal scan operation, the average of the offset data is subtracted from the active data in the ALU. This data is then sent to a ROM for the purpose of data alteration.

Illustration 3–9 Offset correction circuit



Test Pattern Generation

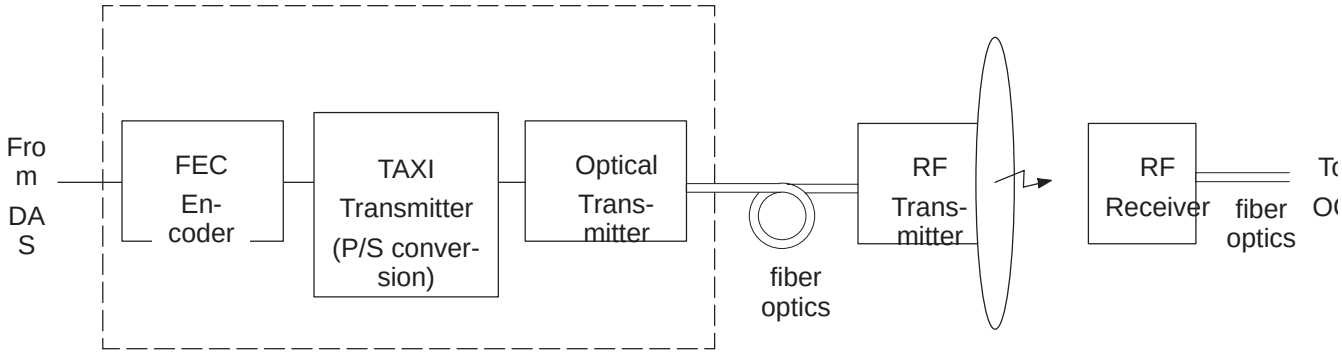
The Test Pattern is for test purpose (DAS data pattern test) that checks the link between DDP board to DAS IFN board (Operator Console).

3-6 DTRF BOARD

The DTRF (Data Transfer with Forward Error Correction) executes the following functions:

- Error correction code generation
- Parallel/Serial conversion
- View packing
- Electric to light signal conversion

Illustration 3–10 DTRF



Error correction code is added for checking the transmitted data at DASIFN assy in the Operator Console to assure data accuracy.

The optical transmitter converts the electric signal to light signal, which is sent to RF transmitter by cable optics. The RF transmitter sends the signal to RF receiver on the stationary gantry, where the signal is again converted to light signal and sent to Operator Console by fiber optics.

For details about data communication, error correction and other information, refer to DASIFN in the Operator Console.

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X–RAY GENERATOR

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SECTION 1 – GENERAL DESCRIPTION – I

1-1 GLOSSARY

Glossary of terms used in this document:

Term	Definition
ABC	Automatic Brightness Control. Regulation loop which makes the measured brightness equal to brightness demand
AEC	Automatic Exposure Control. Exposure cut off technique which uses the brightness signal to cut the exposure
CAN	Controller Area Network. A network used for localized control.
CPU	Control Processor Unit. Microprocessor and peripherals which run the software/firmware
EPLD	Erasable Programmable Logic Device.
EMC	Electro Magnetic Compatibility. The EMC function prevents the generator from polluting the power source.
FPGA	Field Programmable Gate Array. It is programmed by the CPU core after the reset and handles all the exposure control logic including the system interface real-time lines.
HV Ripple	High voltage variations due to inverter current pulses. Typically a few percent.
State Machine	Software or hardware function which handles the state of a system and authorize to go to the next state upon reception of specific events.
IGBT	Insulated gate bipolar transistor. A type of power switch
I_{lp}	HV power inverter parallel resonant current; current in the parallel inductor
I_{lr}	HV power inverter serial resonant current; current in the serial inductor.
MOS	Metal Oxide Semiconductor. A type of power switch
OGP	On Gantry Processor. Unit which drives the generator in CT systems
PDU	Power Distribution Unit
RMS	Root Mean Square

1-2 JEDI HIGH LEVEL BLOCK DIAGRAM

Illustration 1–1 Jedi Generator / Np+ Functional Architecture

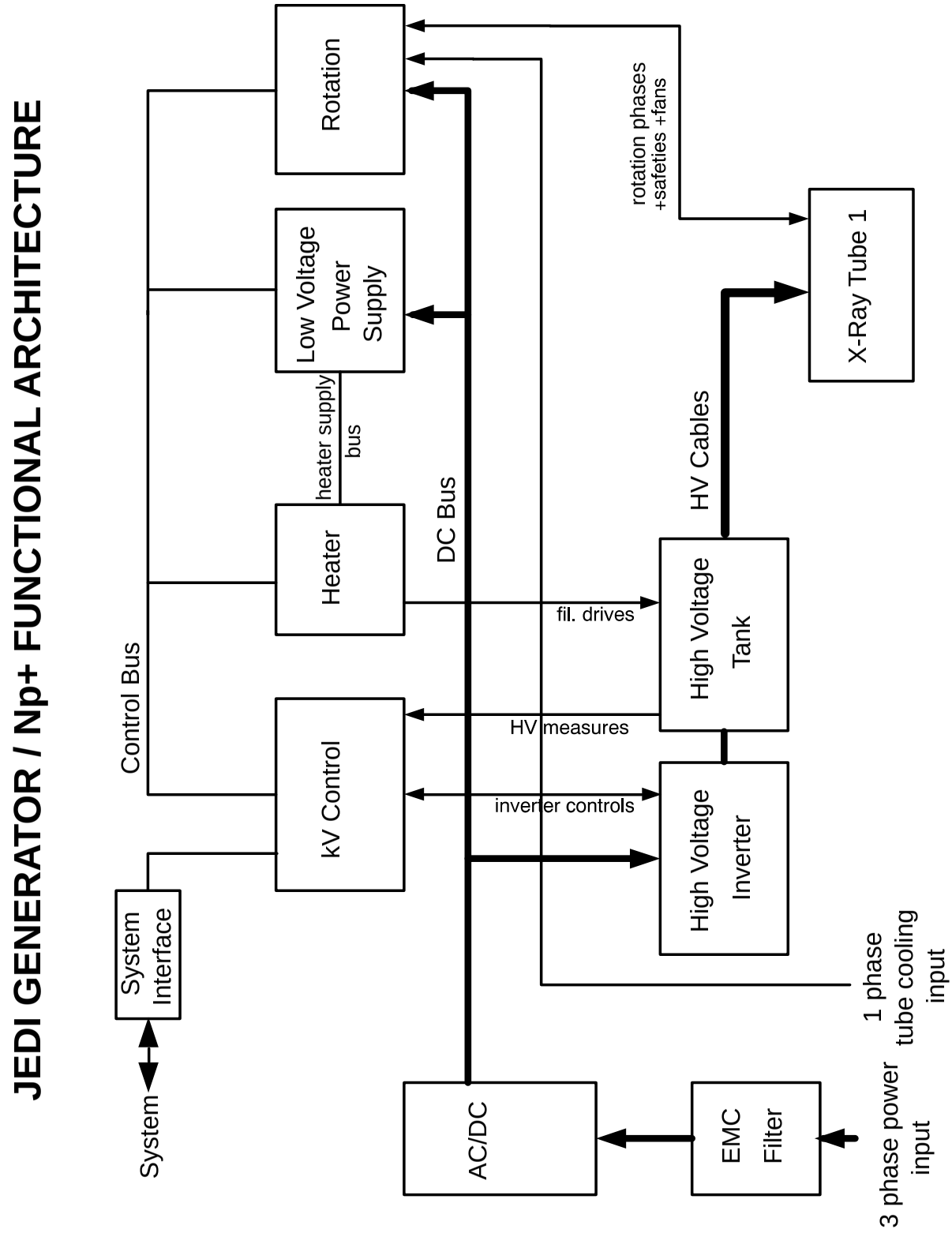
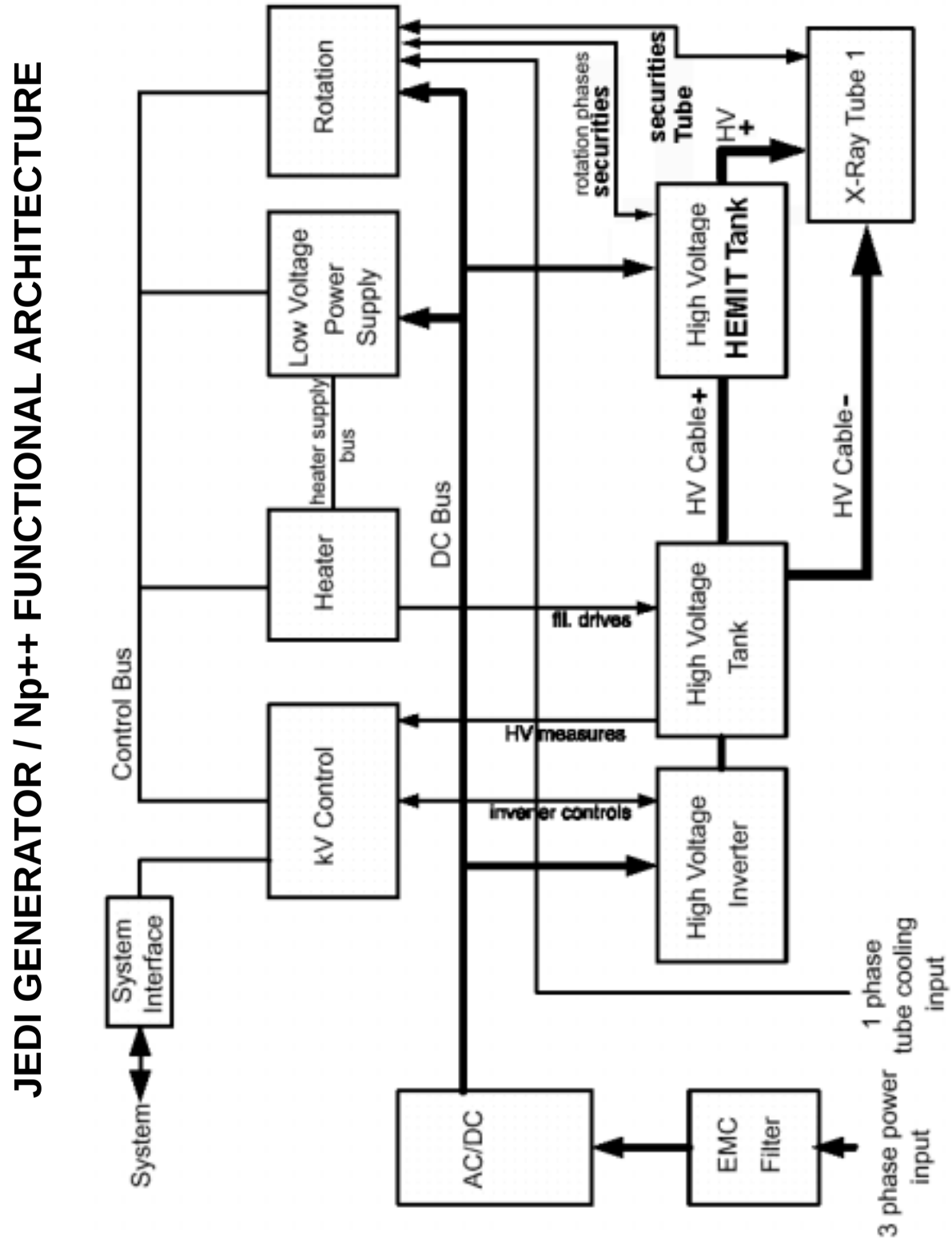


Illustration 1–2 Jedi Generator / Np++ Functional Architecture



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SECTION 2 – GENERAL DESCRIPTION – II

2-1 INTRODUCTION

Jedi is the engineering name for a family of compact high frequency X–Ray generators. This generator family covers a wide range of applications from mobile equipment up to vascular systems:

- JEDI 12–25 kW: Mobile applications
- JEDI 24–48 kW: CT applications
- JEDI 32–50 kW: RAD applications
- JEDI 50–65–80 kW: RF applications
- JEDI 100 kW: VASCULAR applications

2-2 STANDARD FEATURES

Jedi is a family of 150 kV generators operating from 12 kW up to 100 kW for all the major radiological, fluoroscopic and CT applications. The family handles 1 ms to continuous exposures with tube currents ranging from 0mA up to 1000 mA.

The generators feature the very latest technology available:

- Constant potential independent of line voltage variations
- Power generation by a high–frequency converter (High voltage ripple: 40 kHz–140 kHz)
- Distributed micro–processor controlled functions (CAN bus)

Other features include:

- Single phase, three phase or battery power source
- Very low kV and mA ripple, excellent accuracies and dose reproducibility
- Compatible with a wide range of tubes, high speed or low speed, can supply up to 3 different tubes. Thermal load interactive integrator ensuring optimum use of the heat protection curve of the x–ray tube
- Available in various packaging configurations: gantry, under–table, cabinet
- Serviceability: high reliability, fast installation (no generator calibration), application error codes ensure fast troubleshooting
- Meets CE marking (and in particular EMC), IEC, UL, CSA, MHW regulations (if required)
- Optional pulsed fluoroscopy

2-3 APPLICATIONS

	RAD	Surgery	RF	Vascular/ Cardiac	CT
3 Points Mode	X		X	X	
2 Points Mode	X		X	X	
1 Point Mode	X		X	X	
0 Point Mode			X	X	
AEC	X		X	X	
Tomography	X		X		
AET	X		X		
Continuous/Pulsed Fluoroscopy		X	X	X	
Rad Exposures		X			
Cinema 30 fr/s		X			
Cinema 90 fr/s				X	
ABC			X	X	
Variable mA Scans					X
Low mA Fluoroscopy					X

Legend:

– AEC – Automatic Exposure Control

– AET – Automatic Tomographic Exposure

– ABC – Automatic Brightness Control in fluoroscopy

2-4 ARCHITECTURE

Refer to Illustration 2–1: Jedi Generator / Functional Architecture

The Jedi family is composed of 3 elements:

2-4-1 A Kernel

- High voltage chain composed of kV control, HV power inverter and HV tank
- Anode rotation function
- Tube filaments heater function
- Control bus for communication between the functions
- DC bus for power distribution to each function
- Input voltage to DC conversion: AC/DC function
- Low voltage power supply
- Application software, running on the kV control board

These functions are the Jedi core. They are present in all versions of the generator.

A function can be unique for all products, or can have several different releases based on product specification.

Examples:

The anode rotation function is available in 2 releases:

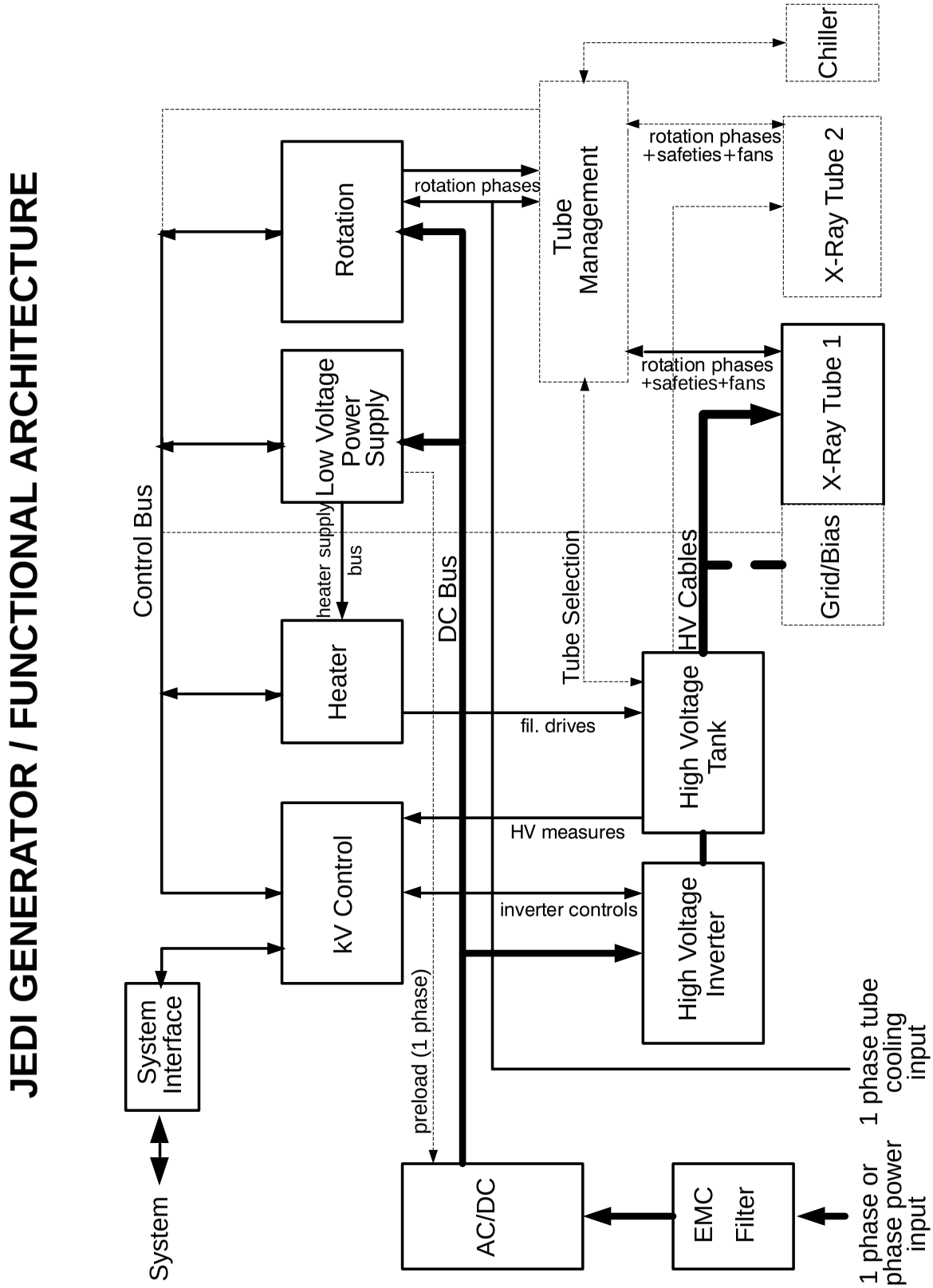
- low speed rotation for applications where the tube has a max rotation of 3000 rpm
- high speed/low speed rotation for applications where at least one of the tubes can use 8000–10000 rpm

The control bus is unique.

2-4-2 Options Depending on the Application

- A System Interface which can be:
  - CT interface
  - RAD interface (console interface, room interface, AEC management present or not)
  - ATLAS interface
- EMC function
- Grid function (RF, vascular)
- Bias function (RF, vascular)
- Tube management (2 tubes or 3 tubes option)

Illustration 2–1 **Jedi Generator / Functional Architecture**



2-4-3 A Packaging Architecture

The packaging architecture consists in a set of boxes which can be put together in several ways to make Jedi fit either in a cabinet, or a console foot, or a table foot. The boxes can also be split in 2 units distant of several meters (example: CT gantry). Refer to Illustration 2–2.

The boxes normally consist of the following:

Auxiliaries Box

- Rotation function
- Heater function
- Low voltage power supply (which can also be in the AC/DC box)

This box is always present.

Power Box

- HV tank
- HV power inverter
- kV control
- System interface (for the less complex system interface)

This box is always present.

AC/DC Box

- MC filter (optional)
- AC/DC function
- Low voltage power supply (which can also be in the auxiliaries box)

This box is always present.

System Interface Box

- RAD interface
- AEC interface

This box is present in the RAD product.

HEMIT (High efficiency motor insulated transformer)

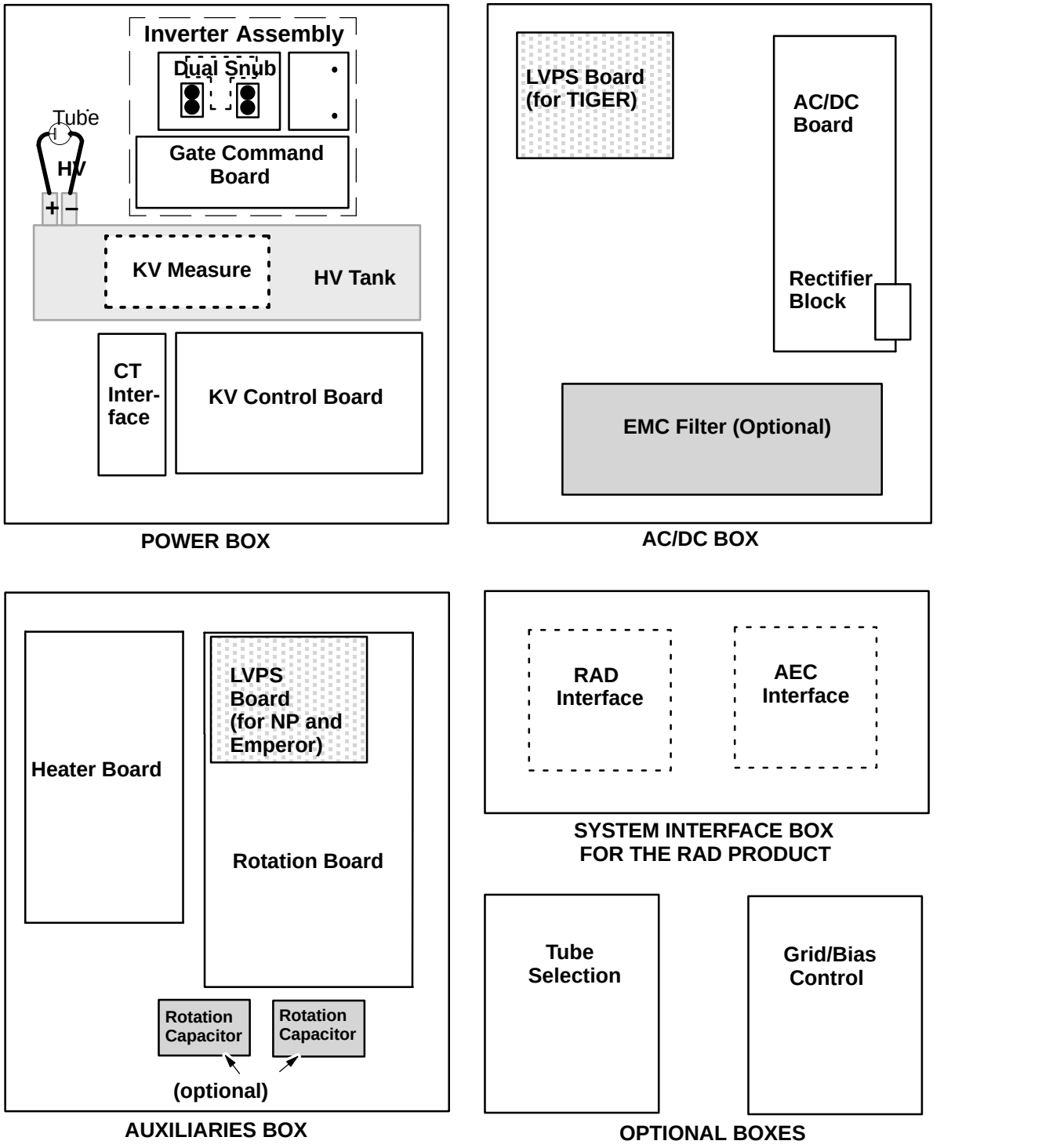
- HV HEMIT Tank (transformers in high voltage)
- DC–Disch board (to discharge the recovered energy of the rotor and securities)

This box is present with non insulated stator tubes (Performix on NP++ and Ebisu, for example)

Optional Boxes

- Tube selection
- Grid/Bias control

Illustration 2–2 Jedi Generator / Packaging Architecture



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SECTION 3 – TYPICAL SIGNALS

3-1 NP+ JEDI TYPICAL SIGNALS

The following table describes the main signals of the generator. For each of them, typical values are presented for the main applications:

Signal/Application	NP+Values (36 kW max, Qj tube)
Anode Rotation:	
Phase P current during high speed run	2 A peak / 144 Hz
Phase A current during high speed run	2 A peak / 144 Hz
Filament Drive:	
Inverter current in standby 2.5 A	3.3 A peak / 35 kHz
Heater DC input voltage in standby	160V
kV Control:	
DC bus measure at 400 VAC	560 V
ILR at full power at 400 VAC	500 A peak / 50 kHz
ILR at min power at 400 VAC	80 A peak / 25 kHz
ILP at full power at 400 VAC	150 A peak / 50 kHz
ILP at min power at 400 VAC	150 A peak / 25 kHz

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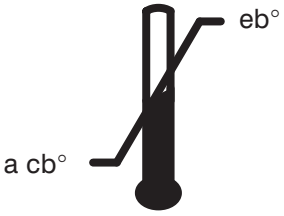
APPENDIX A – SYMBOLS AND CLASSIFICATION

Symbol	Publication	Description
	417–5032	Alternating Current
	335–1	Three–phase Alternating Current
	335–1	Three–phase Alternating Current with neutral conductor
		Direct Current
	417–5019	Protective Earth (Ground)
	348	Attention, consult ACCOMPANYING DOCUMENTS
	417–5008	OFF (Power: disconnection from the mains)
	417–5007	ON (Power: connection to the mains)
		Warning, HIGH VOLTAGE
		Emergency Stop

Symbol	Publication	Description
		Type B
	417–5339	X–ray Source Assembly Emitting
	417–5009	Standby
		Start
		Table Set
		Abort
		Intercom
		(on Operator Console) Power On: light on Standby: light off

Symbol	Description
	Microphone (Mic)
	Contrast
	Brightness
	**System storage prior to installation:** Maintain storage temperature between –10° C and +60° C
	System storage prior to installation: Maintain non–condensing storage humidity below 95% DO NOT store system longer than 90 days
u r r f dba cbebt o	**System storage and shipment**: Maintain Air Pressure between 750 and 1060hPa

CLASS 1 EQUIPMENT

Any permanently installed equipment containing operator or patient accessible surfaces must provide backup protection against electric shock,in case the BASIC INSULATION fails. In addition to BASIC INSULATION,Class1 equipment contains a direct connection to a PROTECTIVE(EARTH) CONDUCTOR which prevents shocks when a person touches a broken piece of equipment or touches two different equipment surfaces simultaneously.

TYPE B EQUIPMENT

CLASS I, II, or III EQUIPMENT or EQUIPMENT with INTERNAL ELECTRICAL POWER SOURCES provide an adequate degree of protection against electric shock arising from (allowable) LEAKAGE CURRENTS or a breakdown in the reliability of the protective earth connection.

ORDINARY EQUIPMENT

Enclosed EQUIPMENT without protection against the ingress of water.

OPERATION 0f EQUIPMENT

CONTINUOUS OPERATION WITH INTERMITTENT LOADING.

Operation in which EQUIPMENT is connected continuously to the SUPPLY MAINS. The stated permissible loading time is so short that the long term on–load operating temperature is not attained. The ensuing interval in loading is, however, not sufficiently long for cooling down to the long term no–load operating temperature.

EQUIPMENT not suitable for use in the presence of a FLAMMABLE ANESTHETIC MIXTURE WITH AIR or WITH OXYGEN or NITROUS OXIDE

CLEANING

The ProSpeed S series system is NOT WATERPROOF. It is NOT designed to protect internal components against the ingress of liquids.Clean external system surfaces(Gantry,table,consoles and accessories)with a soft cloth dipped in hot water and wrung DAMP/DRY. (NOT dripping!) IF NECESSARY, use only mild (dish washing liquid) soap to remove dirt.

NOTICE

Avoid damage to equipment! Some ”spray and wipe”cleaners etch and permanently cloud clear plastic surfaces!! Use only warm water and mild liquid soap to clean surfaces.

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